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Of the Vegetation of Swamp, Clay, and Sandstone Areas in Western Wisconsin, Southeastern Minnesota, Northeastern, Central, and Southeastern Iowa

BY L. H. PAMMEL

[Reprinted from Volume X, Proceedings of the Davenport Academy of Sciences, Davenport, Iowa.]

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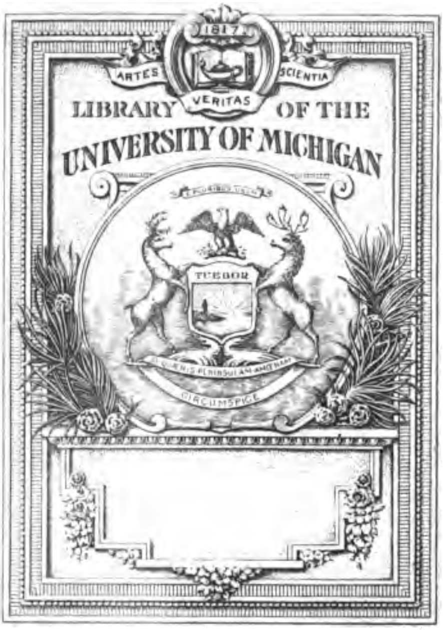
1905



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A Comparative Study

Of the Vegetation of Swamp, Clay, and Sandstone Areas in Western Wisconsin, Southeastern Minnesota, Northeastern, Central, and Southeastern Iowa

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BY L.ouis H.ermann PAMMEL

[Reprinted from Volume X, Proceedings of the Davenport
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A Comparative Study of the Vegetation of Swamp, Clay, and Sandstone Areas in Western Wisconsin, Southeastern Minnesota, Northeastern, Central and Southeastern Iowa.

BY L. H. PAMMEL.

In presenting this paper the writer has attempted to bring together certain interesting facts pertaining to the flora of a few isolated areas of Iowa, Wisconsin, and Minnesota, calling attention to the local distribution of some plants and their relation to the physiographic condition of the region.

In the year 1883, when a student at the University of Wisconsin, I began the study of the flora of southeastern Minnesota and western Wisconsin. A collection of plants was made, and added to from time to time since. Little, however, has been published on the flora that is interesting from a geographical standpoint. The local distribution of a few of these plants depends upon physiographic conditions peculiar to the region. Some time has also been spent in studying the flora of central Iowa. Here again we have some interesting local physiographic conditions, and a few plants that are local in their appearance. These rare plants are found upon the sub-carboniferous sandstone of the region. The writer has also had an opportunity to study the peculiar flora in Muscatine and Marion counties, with small outcrops of sandstone. These areas likewise contain plants that are in part quite local to the regions.

Published accounts of the flora of the regions named are not numerous. The best paper treating with the ecological aspects of the region is that by Prof. Wheeler on the flora of southeastern Minnesota.[1] Prof. Wheeler, however, made a study of Winnebago and Crooked creeks in Houston county only. After a brief discussion of the physiography of the region, Prof. Wheeler treats the formations under the following heads: Plankton; attached, submerged, aquatic plants; attached aquatic plants with natant leaves; adaptive shore plants; wet meadows of the river valley, mud flat vegetation, creek valleys, cold spring vegetation, pond vegetation, wet vegetation of the creek valleys, moist wood vegetation, mesophytic field vegetation, moist cliff vegetation, vegetation of wooded slopes, ridge forest vegetation, base slope and open ridge vegetation and dry rock vegetation.

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[1] Wheeler, W. A.—A Contribution to the Knowledge of the Flora of Southeastern Minnesota. Minn. Bot. Stud. 24: 353-416. Pl. 21-27.

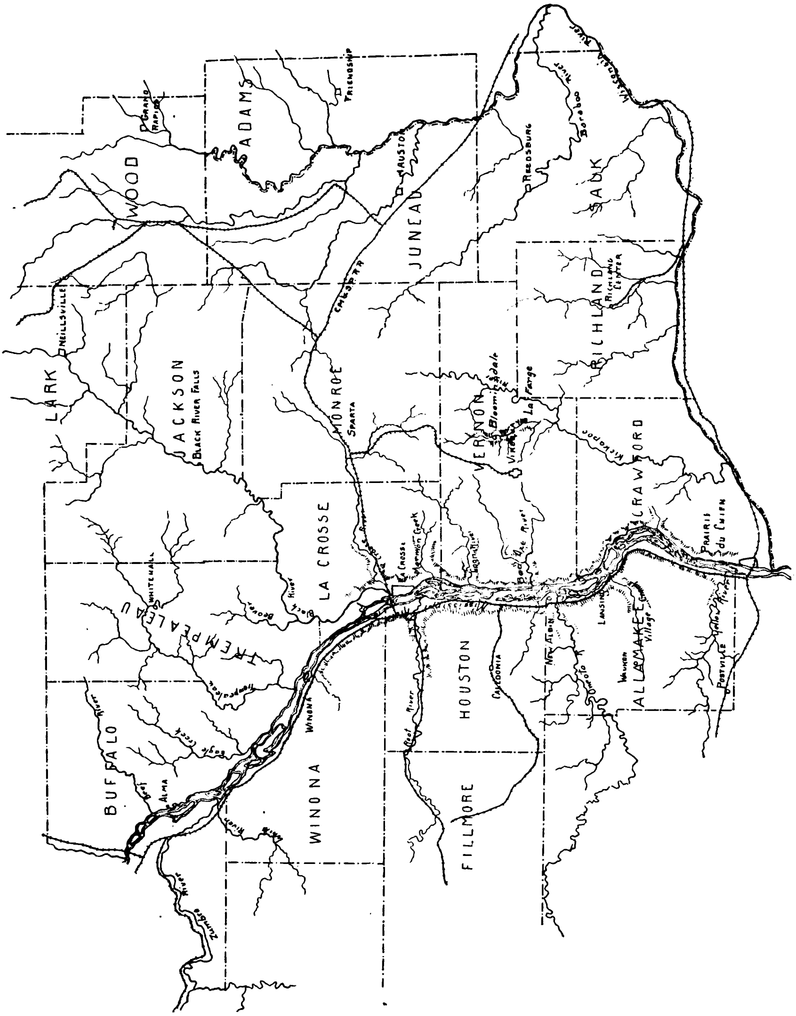

FIG. 1. Map of Western Wisconsin, Southeastern Minnesota and Northeastern Iowa. Charlotte M. King.

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Lueders, in his account of the vegetation of the town of Prairie Du Sac, in Sauk county, as well as the paper by Dr. Parry, considers the physiographic conditions as having an important bearing on the distribution of plants. The paper by Wheeler gives a good analysis of the flora and of the different formations. The following systematic papers[1] should be mentioned: The paper by L. S. Cheney and R. H. True on the flora of Madison and vicinity, and papers by the writer and Prof. Greene, also papers by Prof. Macbride on trees and shrubs of Allamakee county.

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[1] Barnes, Reppert and Miller. The Flora of Scott and Muscatine Counties; Proc. Davenport Acad. of Sci. 1900: 199.

Reppert, Fred. Forest Trees and Shrubs of Muscatine County. Ia. Geol. Surv. 9: 380-388.

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Lueders, H. F. Trans. Wis. Acad. Sci., Arts and Letters 10: 510-524, Pl. 17.

Macbride, T. H. Forestry Notes for Humboldt Co. Iowa Geol. Surv. 9: 147-154. Iowa Geol. Surv. 4.

Mueller, H. A. Trees and Shrubs of Hamilton Co. Pro. Ia. Acad. Sci. 7: 204-209.

Pammel, L. H. Plant World 1: 154; 4: 151.
Rep't Minn. State Hort. Soc. 1887: 469.
Proc. Ia. Acad. Sci. 9: 152-180, f. 7-17.
Flora of Story Co. Ia. Geol. Surv. 9: 239-245.

Pammel, L. H., and King, Charlotte. Proc. Ia. Acad. Sci. 9: 134-151. Pl. 10-31.

Parry, C. C. Owen Rep't Geol. Sur. of Wis., Ia. and Minn. 606.

Shimek. Notes on the Aquatic Plants of Northern Iowa. Proc. Ia. Acad. Sci. 4: 77.
Notes on the Flora of Iowa. Bull. Lab. Nat. Hist. S. U. 3: 195.
Iowa Pteridophyta. Bull. Lab. Nat. Hist. S. U. I. 5: 154-170.

The paper by Dr. Fink on the Spermaphyta of Fayette, as well as notes by Shimek on the Aquatic Plants of Northern Iowa and Notes on the Flora of Iowa, and the paper by Cratty on the aquatic plants, touch upon interesting phases of the flora included in this article. The paper by Cameron on the Trees and Shrubs of Delaware County, and the very excellent paper by Barnes, Reppert and Miller on the Flora of Scott and Muscatine Counties touch upon the floras peculiar to some of the regions of the state.

For the sake of convenience, we will discuss the subject under the following heads: Topography, Geology, Climatology, Physical Properties of Soils, Chemical Properties, Bacteria of the Soil, Plant Formations, The Algal Flora, and Local Problems in Geographical Distribution.

TOPOGRAPHY.

WESTERN WISCONSIN, SOUTHEASTERN MINNESOTA AND NORTHEASTERN IOWA.

The region here considered is embraced in the counties of La Crosse, Trempleau, Vernon and part of Monroe. The region is well watered, containing several perennial streams of considerable size. The Black River rises northeastward and flows through a country once heavily timbered with white pine. The Kickapoo, with its several branches, rises in Monroe county where there are many swamps which are in part drained by the eastern part of the Kickapoo River, while the northern part of the county is swampy in many places and drained by the Lemonweir River, which flows into the Wisconsin River below Mauston.

The La Crosse is the smallest of the three streams. This rises in Monroe county and drains many small marshes, receiving numerous small brooks and creeks that rise in the hills adjacent to its valley. In part the river has made its way through a Jack-pine plain region near Sparta and small prairie-like openings.

In addition to these streams mention may be made of such streams as the Mormon Cooley, Chipmunk, State-road Cooley, Bostwick, and Smith's creeks and the Bad Axe and Coon rivers. In former times the Mormon, Bad Axe and Bostwick contained a much more even flow of water than at the present time. The flow was more regular, since these streams had water sufficient to run flourishing flour mills during the entire year. The spring water comes from various sources, the best and largest springs coming from the St. Croix sandstone area. Another class rises below the Oneota limestone and the third class rises in the marshes and bogs.

Between La Crosse and Geneva, on the Wisconsin side of the Mississippi, precipitous bluffs face the river, having an elevation of 460 to 500 feet above the flood plain of that river. There are, however, bluffs to the north that are 600 feet above the Mississippi flood plain. The topography of the Minnesota side is essentially the same. There are a half-dozen small streams, the most important being the Root River and Pine Creek. By far the greatest volume of water, however, is carried by the Root River. The higher bluffs on both the Wisconsin and Minnesota sides are generally bare and very dry. The ridges are frequently long and always narrow. Eastward from the Mississippi the bluffs are less precipitous and the ridges widen into flat or rolling areas and these are of considerable size. To the south these areas are common, with quite deep valleys.[1]

The rock exposure toward the Mississippi River consists mainly of St. Croix sandstone of great thickness, capped with a thin layer of Oneota. At the base of the bluffs toward the river are sandy plains; but the valleys vary greatly in width. The soil of the valleys consists of a yellow loam, but near the creeks and rivers it is a black alluvial. Bogs and marshes have formed under favorable conditions. North of La Crosse, and including the Black River district, the hills are low and sandy, often with deep ravines. The Black River district is a network of sloughs and marshes, but in the older flood plains is drier. Here there is a scattered growth of Norway pine, red cedar, swamp white oak and green ash. The sandy uplands often form low prairies of fair fertility. Swamps are, however, common also in other parts of the region. In part, these swamps are surrounded by low hills and terraces. Taking these meadows in the vicinity of La Crosse, close to the mouth of the river, as a typical illustration, we have a marshy plain and an elevated sandy prairie that rises between

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1. Geol. of Wis. 4: 1.

thirty and forty feet above the flood plain of the La Crosse River. On the west side of the Mississippi, except in Houston county, there are swamps and marshes not unlike those on the east side of the river, but they are not nearly so extensive. The same may be said of Allamakee county in northeastern Iowa. At the mouth of Red River and Pine Creek in Minnesota there are extensive alluvial bottoms where soil of great fertility has formed. The back-waters of the Mississippi near the mouth of Pine Creek have formed a lake of considerable size known as Target Lake. In the vicinity of La Crosse, and Houston, Minnesota, as well as New Albin in northeastern Iowa, there is a well-marked terrace formation.

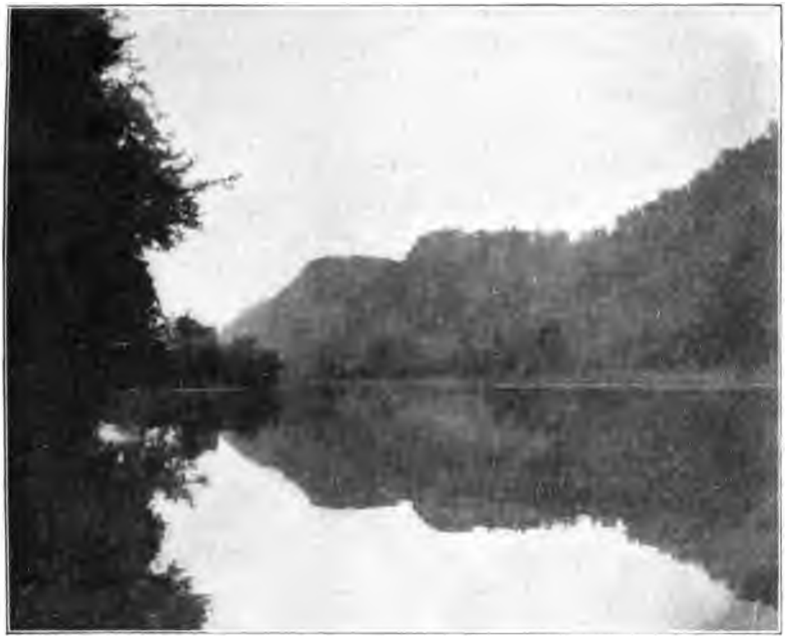

FIG. 2. Bluffs along the Mississippi River near Lansing, Iowa. Hard Maple, *Acer nigra*, on high bank. Basswood, *Tilia americana*, Black Walnut, *Juglans nigra*, on banks above the alluvium. Black Birch, *Betula nigra*, Cork Elm, *Ulmus racemosa*, Soft Maple, *Acer saccharninum*, on alluvium. Photograph by Charlotte M. King.

Moses Strong[1] made three natural divisions in the Wisconsin area here considered. First, high, rolling table-land cut up by numerous ravines, the larger ones called coulés (Cooley) or valleys, the ridges rising from three hundred to five hundred feet above the flood plains of the Mississippi. Naturally the soil is a clay derived from the Oneota limestone. This includes the south half of Richland, Crawford, La Crosse and Trempleau counties.

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[1] Moses Strong, Geol. of Wis. 4: 1.

The third area includes the alluvial flood plain in the valleys of the La Crosse, Black, Kickapoo and Trempleau rivers. The material is of glacial origin, except parts of the Kickapoo and La Crosse rivers.

The principal streams of northeastern Iowa are the Upper Iowa, Yellow and Turkey rivers. At the mouth of the Upper Iowa a large alluvial bottom has formed. It is similar to that of the Root River. A very good idea of the topography may be obtained from Prof. Calvin's account.[1]

At Postville the elevation is 1200 feet above the sea level. Postville is situated upon the high land south of the Yellow River and Prof. Calvin is responsible for the statement that at the crest between the Oneota River and Village Creek the land is not only higher than any other in the county, but, beyond that fact, it contains the highest land, at corresponding distances from the Mississippi River, between St. Paul and the Gulf of Mexico. In its general topography this region is similar to that found in Vernon county in the vicinity of Viroqua and Coon Prairie.

"In Allamakee county there is no mantle of drift and there are no indications of invasion by glaciers. The topographic characters imposed by long-continued action of solution and mechanical erosion have never been obscured or modified in any essential or fundamental degree. The surface, therefore, is gashed and furrowed in every direction by an intricate system of ramifying erosion channels. Some small areas in the southwestern part of the county are comparatively level. Ludlow and Union Prairie townships present more of the unusual features of Iowa topography than any other portions of the county. Elsewhere throughout the county topographic forms are bold. Rounded, steep-sided ridges, with gorges and ravines sharply angled at the bottom, prevail except in or near the valleys of the main drainage streams."

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1. Ia. Geol. Surv. 4: 2.

CENTRAL IOWA.

For central Iowa two areas will be considered: parts of Hardin and Marshall counties along the Iowa River, and Boone and Story counties along the Skunk and Des Moines rivers.

Hardin and Marshall Counties.— The drift sheets have influenced the general topography of the region in a marked way. Dr. Beyer[1] divides Hardin county into three topographical provinces. The first is the loess Kansan type which comprises about one-sixth the superficial area of the county. This area is perfectly drained and includes part of the townships of Providence and Union in the southeastern part. The second province is the Iowan drift plains and comprises the south half of Aetna and the northeast half of Clay township. This is a portion of the great Iowan drift plain which extends from Minnesota across the state through

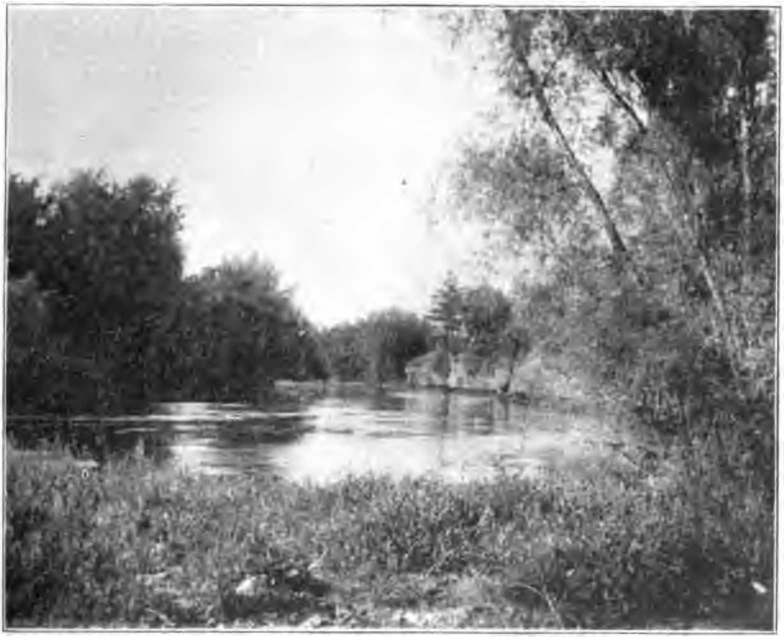

FIG. 3. Sandstone formation in Hardin County. White Pine and Cherry and White Birch in foreground. Photograph by Charlotte M. King.

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[1] Ia. Geol. Surv. 10: 247.

Worth, Cerro Gordo and Franklin counties. Here the streams have done little cutting. The third province is the area covered by the Wisconsin drift sheet and covers more than four-fifths of the county. The eastern margin is marked by the Altamont moraine.

The chief drainage areas under consideration are Pine and Elk creeks, which lie in the Kansan drift. The Iowa River, which flows through the county in a southeasterly direction, entering the county in Alden township, cutting through the Kinderhook series at Iowa Falls, forms a gorge at Iowa Falls with a height of eighty feet. Between Steamboat Rock and Eldora, at several points, ferruginous sandstone faces the river. In the Iowan drift in Clay township the hills are thickly covered with timber and with small alluvial areas. Below Eldora the alluvial areas increase in size, forming a wider flood plain of the river.

Marshall County.—The whole county is covered by drift, but there are three distinctive areas occupied by the Wisconsin, Iowa and Kansan drift sheets which Dr. Beyer[1] designates as the drift, drift plain and drift loess types. In the western part of the county are many sloughs and "kettle holes." The northeastern part of the county is a slightly rolling plain, with sloughs. The drift loess type contains many small streams and numerous hills. Near the Iowa River, extending in a southerly direction, a few miles south of Albion is a sand-bar that traverses the county, extending southwestward. On the east side of the river is an eminence known as Mormon Ridge, which is heavily covered with timber. The principal streams are the Iowa River, Timber Creek and Minerva and Honey creeks.

Story County.—The surface of the county is gently rolling and, as Dr. Beyer says,[2] "it is the typical saucer topography so characteristic of the younger drift sheet." Several prominent moraines occur in the county, the Gary, which enters the county from Boone in Lafayette county to Lincoln township. The Altamont moraine touches the county in its eastern part from Sherman to Collins townships. This marks the western boundry of this moraine. Dr. Beyer gives the altitude of the Altamont moraine near Collins as 1022 feet. The Gary moraine near Summit has an altitude of 1075 feet. The principal streams are Skunk River and Squaw and Indian creeks. According to Dr. Beyer it seems highly probable that the headwaters of the present Des Moines found their way to the Mississippi through the Skunk.

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[1] Ia. Geol. Surv. 7: 203.

[2] Ia. Geol. Surv. 9: 459.

Boone County.— The topography of Boone county has the character of a drift plain. It is flat, except near the streams. The Des Moines, which is the principal river, enters the county in Pilot Mound township and flows in a southerly direction, dividing the county into two parts. The Des Moines valley is narrow, with numerous small tributaries, also narrow, often with gorges. The most important of these are found in the vicinity of Moingona, commonly called the Ledges.

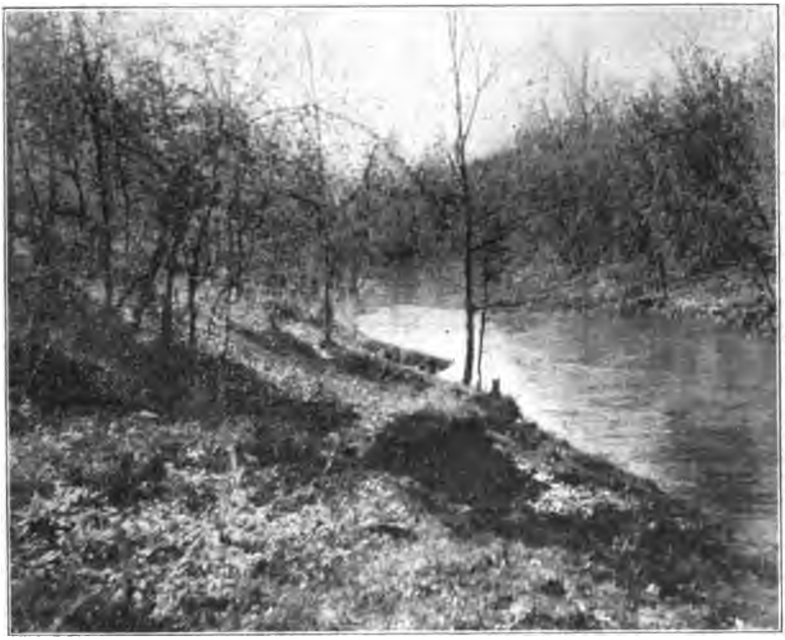

FIG. 4. Story County. Wooded area along Squaw Creek. *Tilia americana* and *Ulnus fulva*. Photograph by C. M. King.

The streams are Bear, Pease, Eversole, Caton, Elk and Bluff creeks. The terraces along the Des Moines River, and other streams, show the recent development of these streams. Squaw Creek, a tributary of Skunk River, drains the northeastern part of the county.

NORTH CENTRAL IOWA.

The bogs are developed altogether in the glacial area.[1] The general landscape is flat and there are very few valleys except for a few of the larger streams. The hills are low and rounded, being especially developed in the northern part of the area, as in Cerro Gordo and Worth counties and the counties westward. Between these hills, especially in the northern area, are small basins. Dr. Bain says "the low swells contain few sharp contours and are not pronounced enough to deserve the name of hills. They have little individuality and are not arranged according to any order or system. Between them lie ill-defined basins occupied usually by shallow ponds, swamps or swale-areas of slough or shallow water. There are very many basins without outlets, and the whole is clearly a region of immature drainage. At many points springs and shallow artesian wells attest the superabundance of water. . . . The numerous lakes and ponds, the undrained sloughs, the peat bogs, the narrow river valleys, the incomplete drainage, the undissected upland between the rivers, some of which flow 200

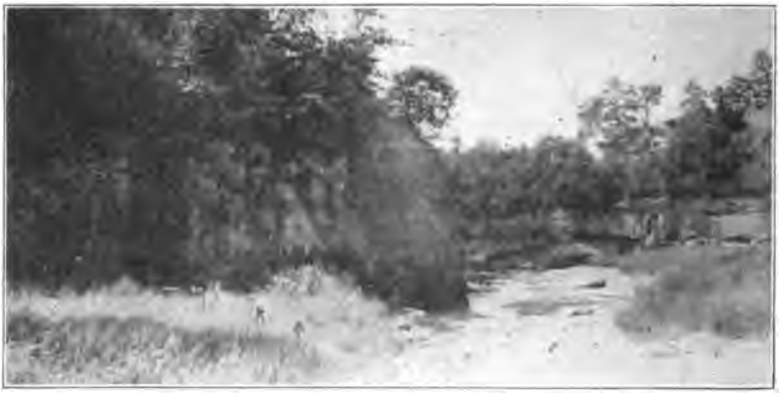

FIG. 5. Ledges, Boone County, Iowa. The dry sandstone exposures, Red, White, and Chestnut Oaks, and Quaking Asp. *Carpinus* and *Ostrya* in timbered areas. Photograph by J. I. Caughey.

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[1] Ia. Geol. Surv. 6: 431.

feet below the general plain, and many other features all point to one conclusion—that the topography is extremely young and that it was formed by glacial agencies."

The region has a number of important streams, the Cedar, with its several branches, rising in Cerro Gordo, Worth and Mitchell counties, the Iowa River in Hancock, one branch of the Des Moines in Emmet county and the other in southern Minnesota. The source of these streams is in several lakes. West of the Des Moines basin the rivers flow into the Missouri. Throughout the entire region there are numerous moranic gravel hills, bogs and marshes. The flood plains of the streams are generally narrow, and the large marshes in Wright county and north are flat. This indicates an ancient lake of considerable size. Similar flat expanses occur in Palo Alto, Kossuth and Humboldt counties.

GEOLOGY.

WESTERN WISCONSIN, SOUTHEASTERN MINNESOTA AND NORTHEASTERN IOWA.

The region here considered lies in the driftless area and so has not been modified by glacial action. The broad valley of the Trempleau River is apparently the boundry below which the glacial deposits were not formed. Opposite La Crosse in Houston county, Minnesota, and along the bluffs east of La Crosse and near the mouth of Mormon Cooley Creek, are small deposits of silicious sand, some clay and small gravel. The rounded pebbles are small and consist of quartz, granite, trap and other archæan rocks. These banks are usually covered with sandy humus. Strong holds that this material was brought down by the Mississippi River from the north.[1]

The greater part of the area in Wisconsin and Minnesota bordering on the Mississippi River consists of the St. Croix sandstone. This formation occurs in valleys frequently forming sandy prairies.

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[1] For a discussion of the formation see Moses A. Strong, Geol. of Wis. 4: 1–98.

W J McGee, The Pleistocene History of Northeastern Iowa, U. S. Geol. Surv. 11: 190.

Samuel Calvin. Ia. Geol. Surv. 4: 42.

Chamberlain and Salisbury. Rept. U. S. Geol. Surv. 6: 286.

The strata in the vicinity of La Crosse and Trempleau attain an elevation of 470 feet. Farther northward the elevation diminishes, becoming the surface rock.

This material is made up of a yellow stratified sandstone, green sandstone and shale, hard, compact yellow sandstone, a heavy-bedded, regularly stratified, hard, white sandstone, and a yellow sandstone. These different layers support a somewhat varied flora, depending upon the slope and the amount of soil covering the rock. In some sections the sandstone is often very ferruginous. The iron found here is a surface deposit derived from the upper ferruginous bed. It is not rich in fossils. The richest fields are found in the southern part of Trempleau and northern part of La Crosse counties. The St. Croix sandstone is exposed in numerous places in Allamakee county, Iowa, according to Prof. Calvin,[1] At Gabbet's Point it rises 300 feet above the level of the river. Towards the head of the Oneota River it is only a few feet

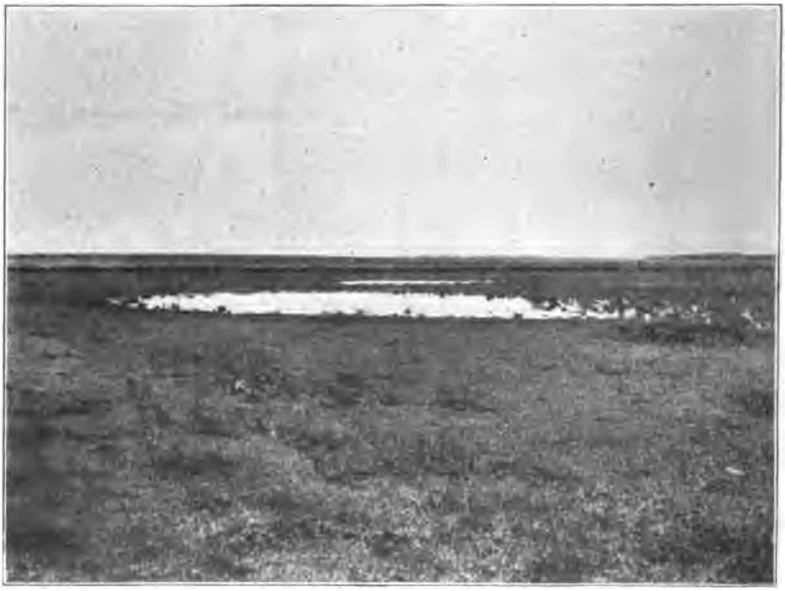

FIG. 6. Kettle-hole in Marshall County, Iowa *Typha latifolia*, *Iris versicolor*, and *Phragmites* are conspicuous plants. Photograph by Dr. S. W. Beyer.

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[1] Ia. Geol. Surv. 4: 55.

above the channel. At New Albin, near the Iowa-Minnesota line, it is given at 320 feet.

The lower magnesium limestone of Chamberlain or the Oneota is the surface rock of the higher ridges about the heads of the small streams and valleys. This limestone covers all of the higher hills along the Mississippi. On one of the highest bluffs along the Mississippi the heavy-bedded limestone is 90 feet thick—thick magnesium layers alternating with sandstone 50 feet, then bedded yellow shales alternating with white and yellow sandstone. The Oneota limestone covers the St. Croix. Calvin[1] says "The Oneota limestone is one of the most conspicuous and at the same time one of the most important of the geological formations in Allamakee county. It lies directly and conformably upon the St. Croix sandstone, the transition from one formation to the other being made through some fifteen or twenty feet of calciferous sandstone." There are few exposures of Galena limestone on the ridges between the Little Kickapoo and the Mississipi rivers.

The St. Peter sandstone occurs in the shape of mounds and cliffs. In the area under consideration it occurs in Vernon, Monroe, and Buffalo counties. It is the surface rocks in part of Vernon county near Coon Prairie on the ridge dividing the Kickapoo and the Mississippi rivers. These ridges are about a mile and half wide, extending in varying widths and broken mounds to Viroqua. Isolated areas occur in Monroe county on the ridge that divides the Kickapoo from the La Crosse River. In the southern part of Buffalo county there are small exposures between Eagle Creek and Trempleau River. The vegetation of the Wisconsin and southeastern Minnesota region is, therefore, largely influenced by the St. Croix and lower magnesium or the Oneota limestone. The St. Croix sandstone and Galena limestone do not show any marked deviation of plants found on the St. Croix sandstone and the lower magnesium limestone.

The St. Peter sandstone in Allamakee county as limited by Calvin[2] is as follows: "Limiting the term in accordance with its original application, the St. Peter sandstone of Allamakee county embraces a body of but slightly coherent arenaceous deposits having an average thickness of about eighty feet, and lying between the fairly well defined summit of the Oneota and the very definitely marked bed of shale that is found everywhere throughout the county at the base of the Trenton."

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[1] lc. 61.

[2] lc. 68.

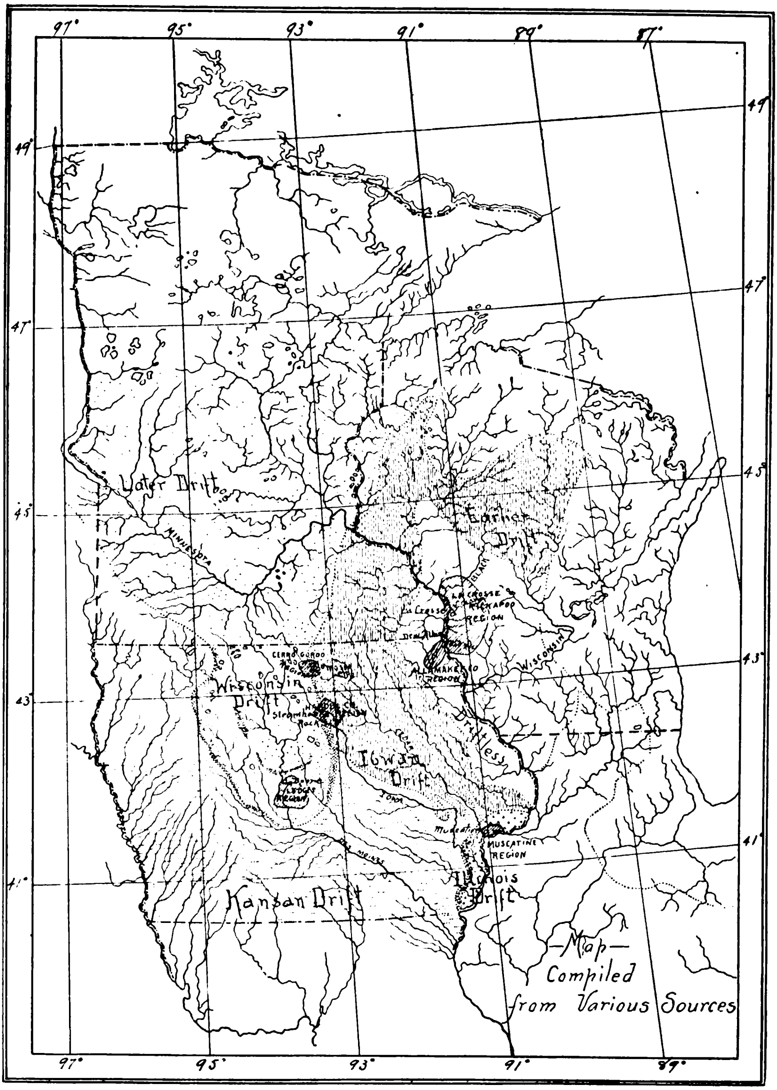

Fig. 7. Geological map showing various drift areas. Map complied from various sources by Charlotte M. King.

CENTRAL IOWA.

Hardin County.—Dr. S. W. Beyer says,[1] "Geologically the county is of especial interest because it is one of the border counties of the productive coal measures, and its surface has been modified by at least three ice invasions." There are two series to the carboniferous system in the county; the first is essentially limestone, which Dr. Beyer refers to the Mississippi series, the second comprises a ferruginous sandstone and shale and is referred to the Des Moines. I shall deal with the flora of the carboniferous sandstone only. Dr. Beyer describes this sandstone as follows:[2] "The beds consist of an upper heavy-bedded ferruginous sandstone which often presents conglomerate to concretionary facies and is cross-bedded throughout; and lower shales which carry some coal and often contain highly calcareous, fossiliferous ledges." These sandstone ledges extend along Pine Creek and some of the smaller streams that are tributary to the Iowa River. These beds reach their greatest thickness about two miles north of Eldora where they are about eighty feet thick. The Wisconsin, Iowan and Kansan drift sheets occur in Hardin county on the Kansan drift. Dr. Beyer[3] says "The Kansan is known to cover the entire county, but is everywhere more or less obscured by later deposits." The drift sheet along the Iowa River between Steamboat Rock and Eldora is the Kansan, overlaid with a loess deposit. The Iowan drift is developed in eastern Aetna and along Clay township. "The most marked characteristics of the Iowan in Hardin[4] county, as elsewhere, are its almost monotonously level surface and its train of giant boulders." The Wisconsin drift covers the western two-thirds of the county. The marginal belt of this is from two to five miles wide, according to Dr. Beyer, and extends "through Marshall, Story, and Polk counties to Capitol Hill, Des Moines, and with the moraine of Cerro Gordo and Worth counties is known as the Altamont moraine." Dr. Beyer,[5] in describing the Wisconsin, says, "As in Story county, certain more or less broken

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[1] Ia. Geol. Surv. 10: 245.
[2] lc. 271.
[3] lc. 279.
[4] lc. 280.
[5] lc. 283.

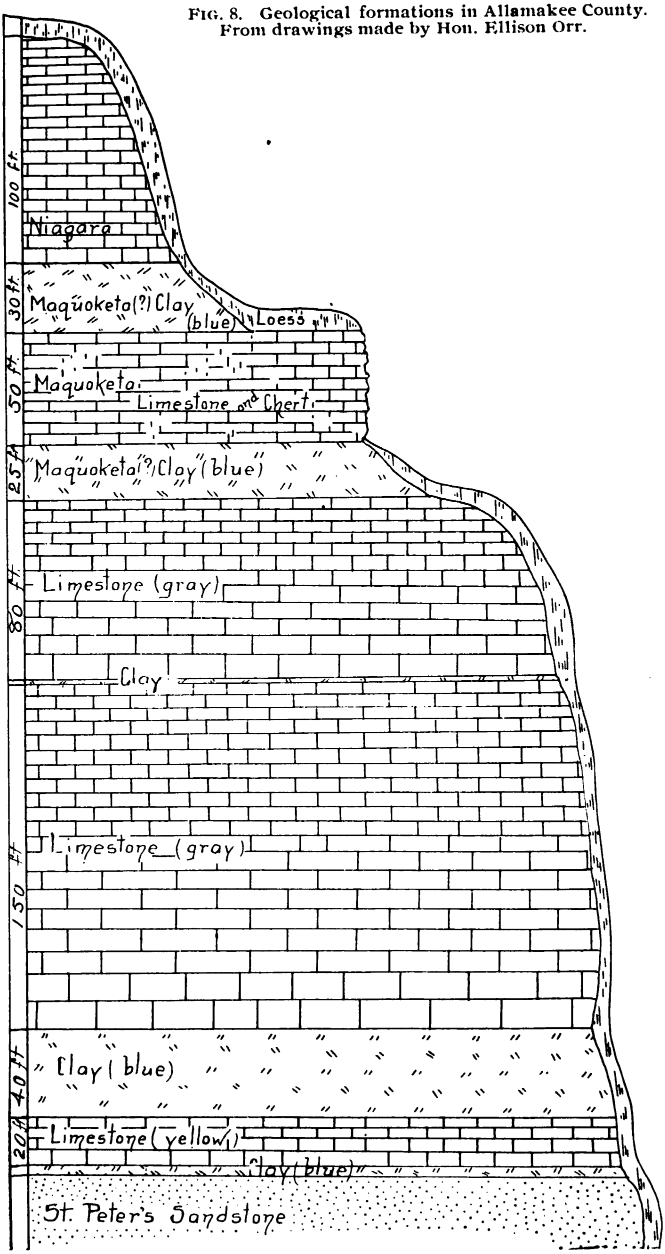

FIG. 8. Geological formations in Allamakee County. From drawings made by Hon. Ellison Orr.

chains of ridges and knobs concentrically arranged may be noted within the area outlined by the Altamont. These concentric chains indicate halts in the retreat of the ice lobe and have been designated recessional moraines by the leading authorities on glacialogy. The general surface or ground moraine of the Wisconsin has undergone very little modification since the retreat of the ice."

Boone County Geology.—In Boone county the geological formations have been referred to by Dr. Beyer [1] in two series, the carboniferous and pleistocene. The lower carboniferous formations occur in this county as well as Story, but are not exposed in Boone county. There is a typical exposure of the St. Louis limestone near the eastern border of the county in Story. Drift material is present everywhere and this varies from 60 to 200 feet in thickness. The Des Moines has cut into this carboniferous formation channel with an average depth of 100 feet, showing exposures of sandstone and shales. Drift material covers the entire county except where it has been removed by the present streams, Dr. Beyer giving the thickness at Zenorsville from 60 to 120 feet, at Boone 200 feet. The county is underlain by two drift sheets, the Kansan, which is only exposed at a few points. Boone county lies wholly within the Wisconsin drift sheet and wholly within the outer loup of the terminal moraine and is bounded by the Altamont moraine. In the northern part of the county there is an ancient moraine, the Garry.[2]

The Cerro Gordo and Worth County Bogs.—It is convenient to consider these bogs in connection with the geology of Boone county as these bogs occur in the Wisconsin drift area. The region here considered is not far from Lime Creek in Cerro Gordo county. It rises in Winnebago county, flows northeasterly across the northwestern part of the county following the morainic belt, in Worth county flowing eastward. Then leaving the moraine, it flows southeasterly over the Iowan drift. The region in Worth and Cerro Gordo counties included in the Altamont moraine consists of numerous "knob-like hills and undrained marshes arranged in the most lawless manner," as so

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1. Ia. Geol. Surv., 5: 184.
2. Ia. Geol. Surv., 5: 203.

well described by Prof. Calvin.[1] "The hills are simply knobs of drift that were irregularly heaped up along the margins of the Wisconsin ice. Their height above the tortuous, marshy valleys that wind in and out and branch and rebranch without definable system so as to practically surround each individual knob, varies from forty to seventy or eighty feet." Kettle holes are numerous. Calvin describes these as follows: "They are abruptly depressed below the surrounding level, but they may be found in all situations from the low, ill-drained ground between the hills to the tops of the highest eminences." In place of these kettle holes peat bogs have taken the place with their decaying plants and the remnants of a boreal flora. The largest of these that I examined occurs in the northwest part of Cerro Gordo and the southwestern part of Worth counties. It covers a considerable area and is an ancient lake bed.

CLIMATOLOGY.

Climatic factors are important in determining the character of the plants found in any given locality. Not only the temperature of the air, the precipitation, the humidity, but the temperature of the soil. Prof. Ganong[2] in an admirable paper on the vegetation of the Bay of Fundy, "Salt and Dried Marshes," takes account of the climatic factors. Schimper, in his great work "*Pflanzengeographie auf Physiologischer Grundlage*," recognizes temperature, light and air as important factors. Nicholas Whitford,[3] in his paper, regards the climatic factors as important in connection with the development of the forest. This subject many years ago was discussed admirably by Dr. Gray in a paper on Forest Geography.[4] The subject is also discussed by Transeau, "On the Geographic Distribution and Ecological Relations of the Bog Plant Societies of North America."[5]

Clements and Pound, in their Phytogeography of Nebraska,[6] discuss the climatic factors. The writer, in his paper on "The

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[1] Ia. Geol. Surv., 7: 133.
[2] Bot. Gazette, 36: 161, 280, 303, 429.
[3] Bot. Gazette, 31: 290.
[4] Am. Jour. Sci. and Arts, 16: 85. 1878.
[5] Bot. Gazette, 36: 401.
[6] Pro. Ia. Acad. Sci., 9: 15. Cont. Bot. Dept. I. S. C., 21.

Physiographical and Ecological Flora of Western Iowa," has shown that climatic conditions are important in considering the peculiarities of the loess flora of western Iowa. Finally, there is a full discussion of the climate and the flora of Mt. Katadin by

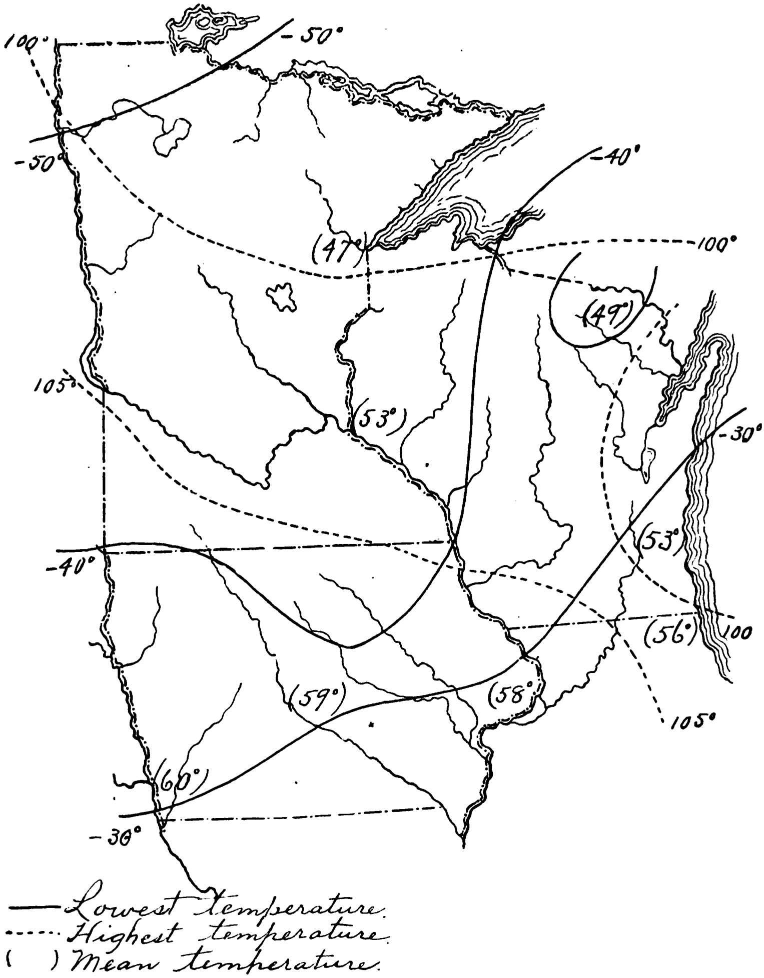

Fig. 9. Map showing minimum and mean temperature for Wisconsin, Minnesota and Iowa. Compiled from various sources by Charlotte M. King.

L. R. Harvey.[1] The subject is also discussed by Coville and MacDougal in a paper dealing with desert conditions of Arizona in which they call attention to the great importance of climatic factors.[1]

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[1] The University of Maine Studies, 5.

The velocity of the wind seriously affects the transpiration of water from plants.[2] This is more marked in central Iowa than in western Wisconsin. It is certainly very marked in western

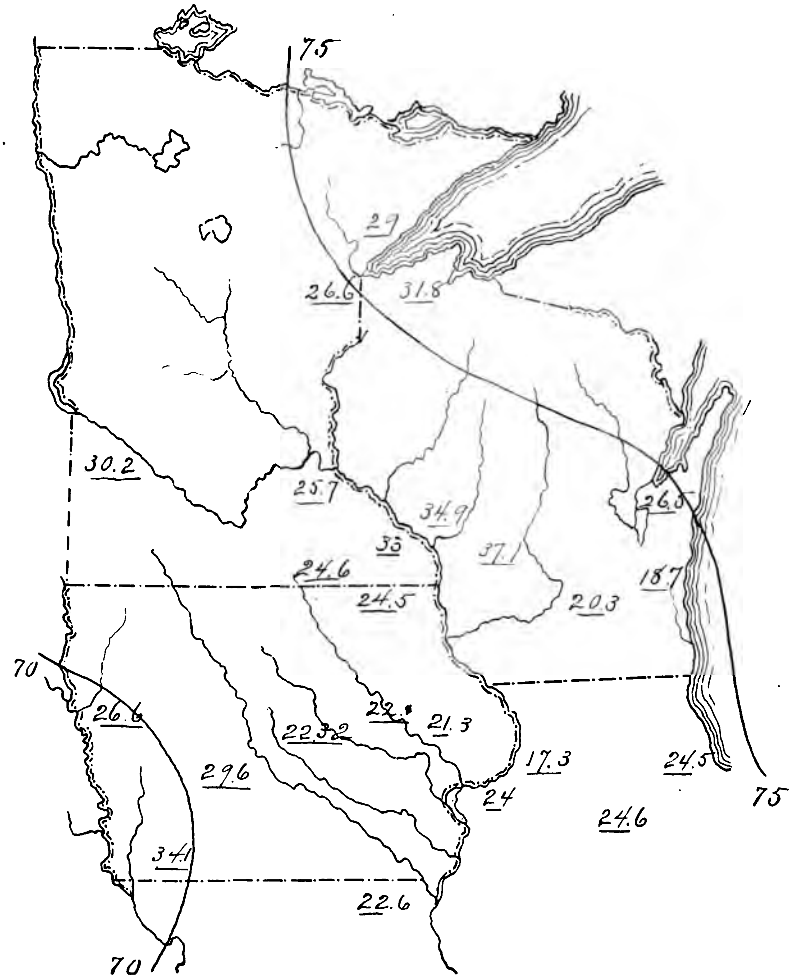

FIG. 10. Map showing normal annual humidity and precipitation for the year 1901; the lines indicate the normal annual humidity, and the figures the precipitation for 1901, a dry year. Compiled from various sources by Charlotte M. King.

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[1] Desert Laboratory of the Carnegie Institution, 6.

[2] Contr. Bot. Dept. I. S. C., 21. Pro. Iowa Acad. Sci., 152.

Iowa, where many of the plants occurring on the loess soil are protected by their thick leaves and pubescence.

For the sake of convenience we shall discuss the subject of climatology under the heads of (1) Precipitation and Temperature of the Different Regions and (2) the Soil Temperatures and (3) Phenology.

Precipitation and Temperature. The time of precipitation and a high mean temperature during the growing period are important in determining the success of an agricultural crop. The same factors apply to many native plants which develop but slowly during the early spring months but attain their best growth when the maximum heat is greater. These plants require long periods of development, as in the Asters, Goldenrods and Thistles. On the other hand, the vernal plants develop at a time when the maximum temperature is much lower, as the Hepatica, Dicentra and Symphoricarpus. Dr. Samuel Weidman[3] gives the precipitation for western Wisconsin for the months of June, July and August from ten to twelve and a half inches; mean temperature for July, 70°; the May mean temperature, 56°; precipitation for March, April and May, 6.5-9 inches; mean temperature for September, 61°; precipitation for September, October and November, 8.5-9 inches; the mean precipitation for December, January and February, 3.5-5 inches; mean temperature for January, 15°.

CLIMATOLOGY AT SEVERAL DIFFERENT STATIONS IN THE STATE OF IOWA.

For the purpose of presenting the more important points the following tables are given, showing the climatology for these points: Lansing in northeastern Iowa, Ogden in central Iowa, Muscatine in southeastern Iowa, and an annual meteorological summary for La Crosse, Wisconsin.

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[3] Wis. Geol. Surv., and Nat. Hist. Surv., 11: 491.

CLIMATOLOGY OF LANSING, IOWA. MEAN TEMPERATURE (DEGREES).

YEAR.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1896						70.5	72.4	71.0	57.9	47.4	32.0	28.2	
1897	17.3	25.2	30.6	48.8	57.9	67.6	75.0	67.8	68.7	57.0	31.2	18.2	47.2
1898	23.4	23.3	37.6	47.0	61.3	71.0	72.6	70.0	65.2	48.2	34.0	17.6	47.6
1899	18.5	12.2	23.7	50.2	60.3	69.5	73.2	71.9	61.9	57.0	44.2	21.8	47.0
1900	24.7	14.9	29.6	51.8	63.4	69.2	72.3	77.6	65.0	58.8	32.6	26.8	48.9
1901	22.6	15.8	33.0	51.4	61.5	71.8							
1902				48.4	63.0	65.6	73.0	68.6	60.1	52.8	40.9	20.4	
Average	21.3	18.3	30.9	49.6	61.2	69.3	73.1	71.1	63.1	53.5	35.8	22.1	47.7

LANSING, IOWA. MEAN PRECIPITATION (INCHES).

YEAR.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1896						4.97	1.64	3.07	4.04	2.45	3.20	0.45	
1897	2.82	0.94	1.70	2.24	0.94	6.53	2.66	1.40	3.03	0.26	0.81	1.22	24.55
1898	0.85	1.70	2.37	3.03	2.38	3.00	3.12	2.37	2.64	5.20	1.93	0.27	28.86
1899	0.53	1.77	2.68	4.12	3.87	6.01	1.11	5.00	1.57	1.27	1.75	2.65	32.23
1900	1.05	1.14	1.69	2.84	4.35	2.03	5.28	3.02	3.55	4.62	1.92	0.37	31.86
1901	0.66	1.08	3.73	1.04	2.97	2.63							
1902				1.08	11.36	3.52	6.87	3.18	3.00	1.76	1.75	2.12	
Average	1.18	1.33	2.43	2.39	4.31	4.10	3.49	3.00	2.97	2.59	1.89	1.18	29.40

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1. Ann. Rept. Ia. Weather and Crop Service, 1902: 32.

CLIMATOLOGY OF OGDEN. MEAN TEMPERATURE (DEGREES).

YEAR.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1894							81.8	77.1	66.	51.9	31.1	29.3	
1895	14.	17.	35.	54.	61.	69.	70.	73.	68.	47.	35.	25.	47.2
1896	23.9	28.8	31.2	54.4	64.8	70.	73.	72.3	58.6	48.2	29.5	31.6	48.9
1897	19.	25.	33.	48.	59.	69.	75.	69.	72.	57.	35.	17.	48.2
1898	23.	23.	37.	49.	59.	71.	73.	72.	66.	48.	32.	17.	47.4
1899	20.5	13.	24.4	48.2	59.6	70.0	72.0	74.1	63.1	58.8	43.4	21.8	47.4
1900	26.2	13.9	31.7	53.4	63.8	68.9	73.3	75.4	64.6	60.2	32.6	24.5	49.1
1901	22.5	17.	33.6	49.4	60.2	70.7	82.2	73.2	65.0	53.5	35.2	21.2	48.5
1902	23.1	17.6	39.4	48.8	64.0	66.1	73.4	70.2	60.7	55.9	43.3	23.3	48.8
Average	21.5	19.4	33.2	50.5	61.4	69.7	74.9	73.0	64.7	53.4	35.2	23.4	48.2

OGDEN—PRECIPITATION (INCHES).

YEAR.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual[1]
1894							.01	2.28	2.44	3.82	.26	.98	
1895	.32	.42	.54	4.13	3.20	5.39	3.41	4.61	2.75	.78	1.74	1.00	28.36
1896	.21	.52	1.00	4.89	9.66	1.70	8.26	2.69	3.82	2.95	1.70	.47	37.87
1897	1.18	.54	1.64	5.24	1.75	1.91	2.13	3.64	3.08	1.32	.29	1.54	24.26
1898	9.2	1.01	2.08	1.46	4.73	5.88	1.69	2.87	3.91	3.91	1.27	.33	30.06
1899	.11	.38	1.36	1.62	7.80	7.21	2.17	3.71	1.25	2.01	1.16	1.65	30.43
1900	.31	1.09	2.09	3.49	4.82	6.30	8.03	8.34	6.86	3.17	.66	.16	45.32
1901	.55	.60	1.61	1.57	2.72	2.76	2.41	1.38	6.87	3.31	.87	1.30	25.95
1902	1.08	.15	1.87	1.23	6.61	7.86	8.87	7.01	3.25	2.69	2.02	1.63	44.27
Average	.59	.59	1.52	2.95	5.16	4.88	4.12	4.06	3.80	2.66	1.11	1.01	32.45

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1. Ann. Rept. Ia. Weather and Crop Service, 1902: 93.

CLIMATOLOGY OF MUSCATINE. MEAN TEMPERATURE (DEGREES).

YEAR.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1879	17.7	23.4	36.4	48.8	63.0	68.7	75.3	70.7	58.8	58.9	38.2	20.4	48.6
1880	35.1	30.0	35.1	48.6	65.1	71.1	75.2	72.8	60.6	48.7	27.4	18.6	49.0
1881	11.1	20.1	28.0	42.7	66.6	69.1	75.2	76.7	69.6	54.0	35.1	35.0	43.6
1882	23.6	36.4	41.2	49.5	55.0	69.3	69.6	69.6	62.7	58.8	38.7	23.3	49.8
1883	9.7	19.0	31.4	56.3	56.2	67.2	69.0	68.3	57.3	47.7	38.0	25.5	45.5
1884	10.4	21.1	32.6	46.9	57.8	66.7	69.8	66.9	67.3	55.8	35.8	19.3	45.9
1885	11.1	10.4	31.0	47.6	66.9	68.2	76.5	68.8	65.0	47.6	37.1	19.6	45.8
1886	14.2	21.2	32.4	50.3	61.2	66.2	77.2	75.4	66.4	65.6	33.7	10.6	47.9
1887	12.5	23.4	34.4	50.8	65.0	77.8	78.4	71.8	50.4	47.7	36.4	24.2	47.2
1888	9.6	20.9	30.6	50.8	55.0	63.2	74.2	70.7	59.2	48.5	38.5	31.2	46.0
1889	25.8	21.4	40.2	50.5	59.6	66.9	73.0	70.0	62.0	49.1	36.7	39.6	49.6
1890	26.7	31.5	29.9	52.2	58.8	73.8	75.7	68.9	58.7	50.6	40.8	29.1	49.7
1891	21.5	25.9	29.0		58.6	72.4	67.8	58.5	66.0	51.6		33.8	
Average	20.2	24.7	35.0	46.9	59.8	68.1	73.0	70.5	62.4	50.3	35.1	24.4	47.5

MUSCATINE—PRECIPITATION (INCHES).

YEAR.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1879	1.20	1.[illegible]7	2.18	1.81	4.54	3.78	3.40	4.56	2.37	2.85	4.65	1.42	3[illegible].83
1880	3.02	1.63	3.62	3.02	3.25	7.[illegible]2	3.84	4.48	3.17	.25	.97	1.31	3[illegible].78
1881	1.34	3.49	2.58	2.11	2.43	0.38	3.77	1.36	6.59	7.03	2.83	1.75	45.66
1882	.84	1.10	2.98	4.00	8.36	8.25	4.55	1.75	1.38	4.29	7.15	2.02	46.67
1883	1.66	4.67	.75	5.00	6.19	4.77	4.31	1.45	1.19	6.23	3.45	1.45	41.12
1884	1.05	1.40	4.28	2.08	5.57	4.63	3.63	5.77	5.23	6.4	1.57	4.42	45.49
1885	2.38	2.21	.25	4.07	4.18	4.81	5.03	7.38	2.88	2.80	.83	2.32	39.[illegible]4
1886	4.21	1.43	4.16	2.62	5.05		.32	2.62	3.05	4.70	.95	.71	
1887	1.88	4.12	1.14	1.26	2.26	2.10	2.90	2.40	3.49	2.24	.98	3.53	28.30
1888	1.49	.70	3.10		6.78	3.82	3.[illegible]9	7.24	2.00	1.50	4.43	2.84	
1889	1.4[illegible]	1.38	.65	4.28	4.17	5.68	6.69	1.15	3.95	1.04	1.65	1.40	33.47
1890	1.90	1.70	3.20	1.12	3.61	6.68	1.88	2.35	2.52	4.24	1.38	1.20	31.87
1891	1.75	2.19	3.50		2.51	4.87	3.29	5.20	1.35	1.49		2.51	
Average	1.81	2.08	2.79	3.41	[illegible].38	4.86	3.91	4.38	3.72	3.04	2.30	2.28	39.22

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1. Ann. Rep. Ia. Weather and Crop Service, 1902: 128.

ANNUAL METEOROLOGICAL SUMMARY. LA CROSSE, WIS.

Summaries are for Year Ending December 31, 1901.

Month.	Mo. Temp.	Relative Humidity 8 a.m.	Precipitation. Inches.	Cloudiness	Total Hours Sunshine Recorded. (Local Time.)
January....	20.6°	81%	.64	6.1	
February...	13.9	81	.64	4.4	
March......	31.0	78	2.16	6.8	
April.......	51.5	66	1.17	5.0	
May........	61.2	73	3.85	4.9	
June........	70.7	80	5.31	4.5	
July........	79.2	73	6.49	3.3	
August.....	72.0	84	.93	2.9	
September..	60.4	86	9.84	5.7	
October....	52.6	83	2.70	4.3	
November..	33.4	79	.74	5.5	
December	18.0	82	.46	6.2	
Average....	4.70	79	34.93	5.0	

U. S. Dept. Agrl., Chief of Weather Bureau, 1901–1902: 102.

ANNUAL METEOROLOGICAL SUMMARY. DAVENPORT, IOWA.

Month.	Mo. Temp.	Relative Humidity 8 a.m.	Precipitation Inches.	Cloudiness	Total Hours Sunshine Recorded. (Local Time.)
January...	26.6°	86%	1.10	4.9	
February...	15.7	91	1.59	3.4	
March......	35.8	83	2.57	6.6	
April.......	50.5	74	.88	5.0	
May........	61.3	74	1.37	4.5	
June.......	74.2	77	3.02	3.3	
July........	83.0	65	1.48	1.9	
August.....	74.2	76	.46	3.4	
September..	65.4	82	2.29	4.3	
October....	55.6	84	.45	3.5	
November..	36.8	82	.79	3.6	
December..	22.8	90	1.33	6.5	
Average....	50.2	80	17.33	4.2	

U. S. Dept. Agrl., Report Chief of Weather Bureau, 1901–1903: 80.

ANNUAL METEOROLOGICAL SUMMARY. DES MOINES, IOWA

Month.	Mo. Temp.	Relative Humidity 8 a.m.	Precipitation. (Inches.)	Cloudiness	Total Hours Sunshine Recorded. (Local Time.)
January....	26.3°	84%	1.01	5.2	166.5
February...	20.0	84	1.11	4.8	181.2
March......	35.8	82	3.02	6.2	181.0
April.......	50.4	78	2.26	5.6	244.0
May........	61.6	75	1.40	4.8	312.7
June........	73.4	78	2.41	4.5	329.1
July........	84.0	68	1.72	3.5	390.1
August.....	75.0	77	.67	4.4	318.9
September..	64.8	83	2.60	5.5	199.9
October....	56.2	81	2.14	4.5	230.0
November..	37.6	80	.40	4.1	212.7
December..	21.9	86	1.03	6.1	144.1
Average...	50.6	80	19.77	4.9	

U. S. Dept. Agrl., Chief of Weather Bureau, 1901–1902: 82.

SOIL TEMPERATURES.

It has long been recognized that the temperature of the soil is an important factor in plant growth, especially in its relation to the development of plants. In a cold soil or stratum plants are necessarily much retarded in their development; in fact, a cold soil produces a much different plant than a warm soil. This is well illustrated in the plants found in the bogs of Worth county and the plants found on the shady limestone rock in Allamakee county. Dr. MacDougal[1], in a paper on soil temperatures and vegetation, discusses the importance of making such observations. These records, however, should be continued.

Temperature records on the soil in wood and field have been kept for some years at this station but, there is no other data except for a few of the published records and a number of additional observations made since. These are inserted here for the purpose of comparing them with records at other places. For records taken at Boone I am indebted to Mr. Wilson and Mr. Morrow. For the records at Ames I am indebted to Mr. Bourne and Mr. Dixon. The records at La Crosse were made by Louis Pammel.

SOIL TEMPERATURE FOR AMES AND LA CROSSE.

LOCALITY.	Soil.	Date.	At a Depth of Six Inches.		
			7 A. M.	12 M.	7 P. M.
La Crosse, Wisconsin.	Sandy	May 6	62	64	68
Ames, Iowa..........	Wis. drift	“ 6	36	40	42
La Crosse............	Sandy	“ 7	62	70	72
Ames................	Wis. drift	“ 7	38	44	47
La Crosse............	Sandy	“ 8	58	58	56
Ames................	Wis. drift	“ 8	39	40	41
La Crosse............	Sandy	“ 9	50	58	58
Ames................	Wis. drift	“ 9	39	44	42
La Crosse............	Sandy	“ 10	46	56	63
Ames................	Wis. drift	“ 10	39	44	46
La Crosse............	Sandy	“ 11	54	60	64
Ames................	Wis. drift	“ 11	40	42	47
La Crosse............	Sandy	“ 12	53	53	56
Ames................	Wis. drift	“ 12	42	44	47
La Crosse............	Sandy	“ 13	52	54	54
Ames................	Wis. drift	“ 13	45	49	50
La Crosse............	Sandy	“ 14	48	54	54
Ames................	Wis. drift	“ 14	45	50	52
La Crosse............	Sandy	“ 15	38	54	60
Ames................	Wis. drift	“ 15	46	52	54
Ames................	Wis. drift	Mar. 29–31	31.6	32.6	33.3

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[1] U. S. Monthly Weather Review, 1903: 379. Repr. Cont. N. Y. Bot. Garden, 44.

SOIL AND AIR TEMPERATURE OF THE LEDGES.

LOCALITY.	Character of Soil.	Date, May 15, 1904.	Temp. of Air.	Temp. of Soil.		Exposure.
				1 in.	6 in.	
Ledges, Boone Co.	Sandy.	2:00 P. M.	62°	54	49	Temp. on rock 71°. West slope.*
" " "	Sandy loam.	2:00 P. M.	57	59	50	Knoll 60 feet high, exposed to sun.
" " "	Loamy.	2:00 P. M.	61	56		Bare ground.
" " "	Loamy.	2:00 P. M.		62		Covered with grass.
" " "	Loamy.	2:00 P. M.			52	Bare ground.
" " "	Loamy.	2:00 P. M.			55	Covered with grass.
" " "	Black sandy loam.	2:00 P. M.	62	50	49	Soil covered with dead leaves.
" " "	Sandy loam.	2:30 P. M.	72	60	56	Exposed south side. Eighty feet high.†
" " "	Sandy loam.	2;30 P. M.	62	55	48	West slope.
" " "	Sandy creek bottom.	2:30 P. M.	62	69	61	Covered with grass.
" " "	Sandy creek bottom.	2:30 P. M.	62	55	49	
" " "	Alluvial.	3:00 P. M.	61	60	55	Des Moines Riv. 2nd bottom. Cult. 1903.
" " "	Alluvial.	3:00 P. M.	64	71	57	Des Moines River. Plowed, 1904.

* Ledge 20 feet high.

† Plants 5-6 days in advance of shady slopes.

In the soil temperatures taken a few years ago at Ames it was found that there is a great deal of fluctuation even in the summer at the depth of from one inch to a foot, but at three feet there is little variation. The amount of covering also influences the temperature of the soil. In 1892 soil temperatures, as well as the temperature in oats and a patch of bachelor's button, were kept during the months of May, June and July.[1] The temperature in the oat field or in the bachelor's button were uniformly lower than the temperature of the air. The table on the following page will show the difference.

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[1] Bull. Ia. Agr. Exp. Sta., 18: 488.

METEOROLOGICAL RECORD, AMES, IOWA.

DATE.	Mean Temp. of the Air.	Precipitation.
May 13	50.6	2.86
“ 24	64.3	
“ 25	62.	
“ 30	67.	
“ 31	52.	
June 1	49 3	3.74
“ 2	55.6	
“ 14	71.3	
“ 15	77.	
June 29	67.6	
“ 30	61.3	
July 1	66.	
“ 2	71.7	
“ 14	78.8	
“ 15	71.8	
“ 30	71.7	
“ 31	72.	

RADIATION THERMOMETER IN OATS.

DATE.	Minimum.	9 A. M.	12 M.	5 P. M.	Mean.
May 13	28		62	56	48.6
“ 24	47	74	65	73	64.7
“ 25	41	76	78	69	66
“ 30	46	65	78	70	64.7
“ 31	48	50	49	50	49.2
June 1	44		47	44	44.6
“ 2	44	66	61	78	62.2
“ 14	51	65	71	66	63.2
“ 15	51	70	75.5	79	68.8
“ 29	49.5	62	73	69	64.3
“ 30	45	60	70	64	62.2
July 1	41		66	62	56.3
“ 2	54	66	63	67	62.5
“ 14	57	73	82	79	72.7
“ 16	50	64	68	75.5	62.1
“ 30	46	65	73	65	62.2
‘ 31	52	68	74	63	64.

PHENOLOGICAL DATA.

The time of blooming of a good many plants has been kept at Ames for a number of years.[1] Notes on a few plants are inserted here. These data have been collected by Miss Charlotte M. King.

PHENOLOGICAL TABLE.

	TIME OF BLOOMING.				
	1896	1901	1902	1903	1904
Acer nigrum	4–26	4–29	4–26		5–15
Acer saccharinum		3–23	4–11	3–17	4–2
Æsculus glabra		5–3	5–11	5–7	
Aster lævis			5–5		
Aster novæ-angliæ			8–20		
Astragalus canadensis			8–20	7–10	
Cratægus mollis		5–3	7–18	5–13	

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[1] Report Iowa State Hort. Soc., 36: 114; 37: 131; 38: 113.

	TIME OF BLOOMING.				
	1896	1901	1902	1903	1904
Cratægus punctata					6-2
Gentiana andrewsii				9-15	
Gentiana quinqueflora				9-10	
Gerardia tenuifolia			8-20		
Geranium maculatum		5-9	5-11	5-12	5-13
Helianthus grosse-seratus					7-28
Heliopsis scabra			6-5		
Isopyrum biternatum		4-23	4-19	4-17	4-20
Lilium canadense				7-10	
Lilium philadelphicum			6-19	6-23	6-16
Lobelia cardinalis				8-18	
Lobelia syphilitica				8-28	
Melilotus alba				6-28	
Monarda fistulosa					7-19
Negundo aceroides	4-10		3-19		4-27
Phlox divaricata			4-28	4-23	5-4
Phlox pilosa			5-9	5-22	6-5
Physocarpus opulifolius		6-1		5-28	6-10
Podophyllum peltatum		5-19	5-4		5-15
Prunus americana	4-19	4-24	4-27	4-17	5-8
Prunus virginiana	5-8	5-7			5-12
Pycnanthenum lanceol'm.					7-18
Pyrus Ioensis	5-2	5-6	5-9		5-8
Pyrus prunifolia		4-27		4-29	
Ranunculus abortivus			4-26	4-16	5-3
Ranunculus septentrion's.				4-18	5-4
Solidago latifolia,				8-11	
Solidago missouriensis					7-20
Solidago rigida		8.20	8-28	8-8	
Taraxacum officinale		3-24		4-7	4-6
Trillium nivale	4-17			3-17	4-3
Verbena hastata					7-22
Veronica virginica				7-10	
Vicia americana			5-31	5-19	5-24
Vitis riparia	5-1	5-18	5-24	6-1	6-10

TIME OF BLOOMING OF PLANTS FOR 1904.

	LOCALITY.			
	Lansing.	Ames.	Elkader.	Davenport.
Anemone thalictroides	5-10	4-22	5-2	4-27
Aquilegia canadensis	5-14	5-13		5-14
Arisæma triphyllum	5-14	5-5	5-27	5-12
Capsella bursa-pastoris	5-9	4-10	4-27	5-2
Claytonia virginica	5-5	4-17	5-3	4-25
Cratægus mollis	5-14	5-6	5-22	5-12
Dicentra cucullaria	4-25	4-17	4-27	4-20
Erythronium albidium	4-30	4-28	5-2	4-27
Geranium maculatum	5-14	5-13	5-14	5-10
Podophyllum peltatum	5-14	5-15	5-22	5-14
Prunus americana	5-5	5-3	5-4	5-7
Ranunculus abortivus	5-7	5-3	5-15	4-30
Ranunculus septentrionalis	5-9	5-4	5-15	
Ribes aureum	5-7	5-5	5-5	5-2
Taraxacum officinale	5-1	4-6	4-27	4-3
Tradescantia virginica	5-25	5-18	6-6	5-30
Uvularia grandiflora	5-6	5-3	5-10	4-27
Viola cucullata	5-1	5-3	5-10	5-7
Viola pubescens	5-7	5-3	5-14	5-7

PHYSICAL AND CHEMICAL PROPERTIES OF SOME TYPICAL SOILS OF THE REGION.

Physical.—The physical character of the soil influences in a marked degree the kind of native vegetation found in the same. Several reports and papers issued by the Bureau of Soils of the United States Department of Agriculture have discussed some of the problems. The Bureau of Soils[1] has carried on some elaborate field investigations and in some instances the work has been applied to the native vegetation. Some interesting work has been carried on by Means and Holmes.

Kearney has given some attention to the study of soil production, and the growth of plants, in alkaline solutions. The question of alkalies and the growth of special plants has been made a subject of papers by Davie and Loughridge.[2] There are not many alkali spots in Iowa. Some of the old lake beds in Northern Iowa show alkali which consists chiefly of magnesium car-

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1. Field Operations of the Divison of Soils. 1902: 333.
   Milton Whitney. Field Operations of Division of Soils. 1900. 2: 274.
   Milton Whitney. Field Operations of the Bureau of Soils. 1901: 3: 647. 95 pl.-25f-31 maps.
   Whitney. Soils in Their Relations to Crop Production. Yearbook U. S. Dept. of Agriculture. 1894: 129.
2. Report U. of California Agri. Exp. Sta., 1895-7. Separate 24.

bonate. This substance forms a white crust on the surface. There is here a poor growth. The *Hordem jubatum* thrives, *Scripus palustris* and *Polygonum Muhlenbergi* make but feeble growth in some old lake beds. *Rumex martimus*, *Scirpus pungens* and *Triglochin* occur. Our soils are usually so well leached that few of these halophytes grow.

Some of the more important plants found in certain alkali soils of the west, like the *Sporobolus airoides*, *Scirpus maritimus*, *Distichlis apicata*, are not found in Iowa though they occur in Nebraska. It has been found by Davie that the Creosote bush, and the Larrea, the *Sporobolus airoides*, and *Distichlis spicata* are confined to special areas.

The physical problems of the soil have long been studied by Dr. Hilgard[1] and no one is more familiar with these problems than he.

Several interesting contributions have been made by Dr. Hilgard, Profs. Loughridge, Snow and Shaw[2] especially on the physical problems connected with the soil and crop production. Attention should also be called to the excellent work by Warrington.

Dr. Ganong has applied some of the problems to a province of the Bay of Fundy Salt Marshes in the Provinces of New Brunswick and Nova Scotia. The Bay of Fundy marsh soil, according to Dr. Ganong, contains but a small amount of clay in comparsion with silt and fine silt. This soil when exposed to the sun becomes very hard, making it difficult for germinating seeds to push their way through. These conditions do not prevail in any of our soils except locally. There is nearly always enough sand to make the soil capable of good areation.[3]

In order to touch our local problems, Dr. J. B. Weems and Mr. C. E. Ellis have kindly made, for the writer, physical examination of some typical virgin soils in Central Iowa and Western Wisconsin. The soils studied here are from widely varying conditions. The first series of analyses are from soils in Boone County, the ledges. The remainder from La Crosse, Wis.

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[1] U. S. Tenth Census Report. Cotton Production of the U. S. Various papers in Rep. U. Calif.

[2] Lectures on Some of the Physical Properties of Soil. Oxford. 1900. Many other works, like Storer's, dealing with agriculture and some of its relations to chemistry.

[3] Bot Gazette, 36: 280.

MECHANICAL ANALYSIS OF SOILS FROM LEDGES. BOONE, IOWA.

	I. Top of the bluff where Populus grandidentata and Quercus alba grow.	II. Where the Reindeer Lichens, Polytrichium juniperium and Polygala senega grow.	III. From the sandy rock where Polypodium vulgare and Mittella grow. Soil dry.	IV. Bottom soil near river. Contains much alluvium. Where Elymus virginicus and Leersia virginica grow.
Coarse gravel	1.1 %	1.1 %		
Fine gravel	4.63	.04	.34%	.40
Coarse sand	2.1	.08	1.10	.55
Medium sand	3.14	.40	12.10	1.85
Fine sand	13.54	7.11	55.82	25.18
Very fine sand	38.84	57.81	12.53	42.79
Silt	11.70	11.03	5.84	9.61
Fine silt	20.89	18.34	8.83	11.80
Clay	1.54	1.14	.70	1.05
Moisture	.69	.51	.10	1.01
Organic matter	3.19	3.55	2.75	5.99
	100.17	100.01	100.11	100.23

The La Crosse soils* are similar to those occurring in northeastern Iowa. They have been selected to show the types of native plants found there. The Tamarack soil originally contained more humus, but by repeated washings has received some sand from tilled soil near by.

MECHANICAL ANALYSES OF LA CROSSE, WISCONSIN, SOILS

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
Coarse gravel								
Fine gravel	.93	.05	.19	.75	15.11	.24	6.38	3.88
Coarse sand	.75	.04	.24	.60	7.78	.26	4.65	1.49
Medium sand	1.12	.05	.64	.87	9.49	.46	6.80	2.80
Fine sand	5.42	.40	9.41	4.55	27.22	6.52	31.27	11.86
Very fine sand	17.68	10.57	49.96	50.99	22.76	38.83	27.82	26.16
Silt	23.32	27.20	22.52	22.89	5.25	17.26	7.38	13.75
Fine silt	14.98	19.53	11.09	9.39	9.56	25.61	11.02	29.62
Clay	.81	1.20	1.87	1.28	.78	1.46	.98	3.19
Moisture	5.60	7.01	1.73	1.69	.46	3.09	.77	2.00
Organic matter	29.42	33.90	5.34	7.34	1.66	6.38	3.00	5.25
	100.03	99.95	99.99	100.35	100.07	100.11	100.02	100.00

No. 1 is a peaty soil. The following plants are found on this soil: *Saxifraga pennsylvanica*, *Cornus stolonifera*, *Caltha palustris*, *Habenaria psychodes*, *Bromus kalmii*, *Lilium canadense*, *Symplocarpus fœtidus*, *Carex* sp.

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*The La Crosse soils were collected by my brother, H. Pammel, and my father, while the soil from the Ledges was collected by Mr. C. E. Ellis, who made the chemical analysis of the soils.

No. 2. An agricultural soil, black sandy humus. *Quercus rubra*, *Q. alba*, *Carya alba*, *Cypriepedium pubescens*, *Panicum macrocarpon*, *Bromus ciliatus*, *Phlox divaricata*, *Corylus americana*, *Festuca nutans*, *Cystopteris fragilis.*

No. 3. Yellow clay on agricultural soil, excellent for small grain and tobacco. *Anemone nemorosa*, *Quercus alba*, *Q. tinctoria*, *Ranunculus fascicularis*, *Phlox divaricata*, *Sanguinaria canadensis*, *Comandra umbellata*, *Polygala senega.*

No. 4. Sandy brownish-black. St. Croix sandstone mixed with humus. *Betula papyrifera*, *Physocarpus opulifolius*, *Dodecatheon media*, *Campanula rotundifolia*, *Aquilegia canadensis*, *Melica mutica*, *Pellæa gracilis*, *Woodsia obtusa*, *W. ilvensis*, *Vaccinium pennsylvanicum.*

No. 5. Brownish sand, St. Croix, little humus. *Betula papyrifera*, *B. lenta*, *Quercus tinctoria*, *Pinus strobus*, *Juniperus virginiana*, *Helianthemum canadense*, *Potentilla argentea*, *Woodsia obtusa*, *W. ilvensis* (dry), *Pellæa gracilis*, *Phegopteris dryopteris*, *Vaccinium pennsylvanicum.*

No. 6. Peaty, wet and mucky. Taken from Tamarack marsh with considerable drift material containing sticks, leaves, cones, etc. *Larix americana*, *Cornus stolonifera*, *Cypripedium spectabile*, *Calamagrostis canadensis*, *Potentilla palustris*, *Maiantherum canadense*, *Caltha palustris*, *Nemopanthes fascicularis*, *Glyceria arundinacea*, *Saxifraga pennsylvanica*, *Viola blanca*, *V. canina* var. *Muhlenbergii.*

No. 7. Sandy soil. St. Croix sand, much coarse gravel and ancient bed of the Mississippi River. A poor agricultural soil. Contains a small amount of moisture. Crops mature rapidly. Suited for early vegetables. Contains little organic matter. *Talinum teretifolium*, *Helianthemum canadense*, *Tephrosia virginiana*, *Cenchrus tribuloides*, *Prunus pumila*, *Cyperus schweinitzii*, *Œnothera rhombipetala*, *Potentilla argentea*, *Oxalis corniculata*, *Hedeoma hirta*, *Delphinium azureum.*

No. 8. Yellow clay similar to No. 3, supporting a somewhat similar vegetation.

These sandy soils have some points of similarity to the soil from the ledges. They support a somewhat similar vegetation. The soil from the ledges is of a much later geological origin.

Chemical.—Several European investigators have discussed the subject of the chemical conditions of the soil with reference to the poorly developed plant forms in bogs.* Ganong† reports on the chemical analyses from the marsh well of Cornwallis Valley, Nova Scotia. The fertility of the marshes is due to the necessary mineral and organic constituents present to produce good crops being present in an unusually large amount, and are in an immediately available form. He then devotes considerable attention to the sodium chloride in some soils and its relation to the growth of plants.

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* Nillson. *Einiges uber die Biologie der Schwedischen Sumpfpflanzen.* Bot.-Cent. 76: 9.
† Ganong. Bot. Gazette. 36: 285.

CHEMICAL ANALYES OF SOME SOILS.

	Insoluble residue....	Soluble silica.......	Alumina.......... Al_2O_0	Ferric oxide....... Fe_2O_3	Lime...... .... CaO	Magnesia .... MgO	Sulphur trixoide.... 30_3	Phosphor. pentoxides P_2O_5	Soda .... Ma_2O	Potash .... K_2O	Moisture........	Loss on ignition.....	Total per cent.... ..
No. 1. Top of bluff at Ledges, Boone........	90.34	.05	2.24	2.16	.57	.39	.11	.13	.36	.26	.69	3.19	100.49
No. 2. Ledges where lichens grow, Boone...	88.17	02	2.26	3.60	.48	.55	.03	.12	.27	.28	.51	3.55	100.04
No. 3. Top of rock where moss grows, Boone	92.97	04	.28	3 00	.96	.33	.10	.15	.18	.19	.10	2.71	100 01
No. 4. Bottom soil near D. M. River, Boone.	83.75	.03	2.10	1.72	3 04	1.41	.08	.25	.36	.26	1.01	5.99	100.00
No. 5. Yellow clay, Ledges, Boone..........	84.12	.05	3.16	3.20	.76	.42	.08	.17	.34	.32	2.04	5 21	100 32
No. 1. Peat, La Crosse, Wis................	58.35	05	2 41	2.40	1.51	.75	.25	.22	38	.21	5 35	28.07	99 95
No. 2. La Crosse, Wis......................	48.17	.05	1.99	2 88	4.26	.81	.42	.44	.27	.11	6.65	33 90	99.95
No. 3. Yellow clay, La Crosse, Wis.........	86.14	.03	3.72	3.04	.50	.41	.06	.20	.22	.11	1.74	3.87	100.04
No. 4. La Crosse, Wis.........	82 07	03	2.97	2 80	.99	.46	.20	.22	.36	.25	1.69	7.39	99.46
No. 5. La Crosse, Wis.........	92 28	05	1 64	1.84	.69	.32	.20	.22	.35	.19	.42	1 80	100.00
No. 6. Boggy peat, La Crosse, Wis....	82.52	.01	4.08	2 72	.7	.68	.07	.19	45	.13	3.05	5 68	100 31
No. 7. La Crosse, Wis.........	88.01	.02	.97	2.24	2.48	1.23	.11	.22	.54	.12	.90	3.17	100.01
No. 1. Earle Buchanan (E. G.).............	70.25	.03	2.73	1.84	4.24	1.16	.34	.20	.37	.24	2 84	15.73	99.99
No. 2. Earle Buchanan (E. G.).............	82 22	.04	3 44	2.08	.62	.44	.14	.39	.35	.12	1 72	8 54	100.10

BACTERIOLOGICAL ANALYSES OF SOILS.

Two recent papers discuss the bacteria found in American soils. In a paper published by Dr. Mayo and A. T. Kinsley of the Kansas Agriculture Experiment Station the number of bacteria found in the sandy loam, in which native buffalo grass was growing, was estimated at 143,000, and the numbers in black loam, in which Alfalfa and Clover were growing was estimated at 21,091,000. A paper by Prof. Frederick D. Chester of Delaware gives the following table to show the relation of numbers of bacteria in the soil to ammonifying and acidifying efficiency:

SOIL.	Total number of bacteria per gram dry soil.	Total amonifying efficiency	Total acidifying efficiency
Experiment Station Garden.......			
1st analysis..................	3,130,000	13.75	2.22
2nd analysis	1,294,000	2.48	1.81
Murray Soil, Viola...............	250,000	2.13	0.69
Killen Soil, Felton...............	540,000	8.90	0.58
Detrich Soil, Chestnut Hill........	4,040,000	26.68	8.57

It is not my purpose here to consider the copious literature on the subject, nor have we attempted to study the subject of nitrification in connection with the soils under consideration. I am indebted to Mr. E. B. Watson and Mr. H. Ness, two special students in the botanical laboratory, for a brief study of the bacteria of some typical Iowa soils.

SOILS FROM BOONE COUNTY.

LOCALITY.	Bacteria per Gram.	Time of Collec'n.
Sandy loam in forest..................	626,420 1,038,078	April 15, 1904
Average.......................	832,244	
Sandy loam, Reindeer lichen formation	31,907 42,485	April 15, 1904
Average......................	37,196	
Polytrichum formation on moist rock..	3,592 030 288,950	April 15, 1904
Average..........	1,950,490	
Sandy bottom.......................	2,560,516 640,124	April 15, 1904
Average..................	1,600,320	
Clay soil	409,024 531,263	April 15, 1904
Average......................	470,143	

SOILS OF LA CROSSE, WISCONSIN.

No.	Nature.	Bacteria per Gram.	Per Cent of Acid Bacteria.	Time of Collecting.
1.	Peat	1,410,000	20	April 29, 1904
2.	Black soil	2,332,000	10	" " "
3.	Clay	2,008,000	25	" " "
4.	Black soil	834,000	25	" " "
5.	Yellow sandy	375,000	0	" " "

PEATY SOILS OF FRANKLIN COUNTY, IOWA.

No.	Nature.	Bacteria per Gram.				Time of Collecting.
1.	From surface	2,467,450				March, 1904
2.	" "	2,940,000				" "
3.	" "	3,937,000				" "
4.	" "	4,725,000				" "
	Average	3,517,362				
1.	From inner portion	27,500	0	28,894	8	Mar., '04
2.	" " "	29,000	1,687	116,052	0	" "
3.	" " "	1,250	5,625,000	492,364	0	" "
4.	" " "	2,500	8,872	746,052	2,140,625	" "
	Average	15,312	1,408,889	345,813	535,156	

Average of all plates.........576,300

It will be seen from these results that a very large number of organisms appear in all of the soils, and that a great percentage of the species, especially in La Crosse soils, are acid producing, the largest number of organisms being found in the black, arable soils, while the smallest number of the organisms are present in the sandy loamy soils. They referred some of the species to the following: *Bacillus albus*, which, in addition to the characters given, had the property of reducing nitrates to nitrites; *Bacillus delicatulus*, or perhaps the *B. venenosur liquefaciens*, also reducing nitrates to nitrites. It is believed by Dr. Vaughan that the *B. venenosus* is pathogenic. It has been found in water supplies. These organisms were found in peat. In the black soil the organisms appear to be *Bacillus rubescens* and *B. epidermidis*, both reducing nitrates to nitrites. In the clay soil were found *Bacillus venenosus* and in the black soil *Cicrococcus agilis*. The *B. venenosus* only slightly reduced nitrates to nitrites. The *Microccus agilis* reduces the nitrates very slowly.

The peat soil from the bogs of Franklin county contained the following organisms: *Microccus citreus*, *Bacillus incanus*, *B. albus*, *B. delicatulus*, *B. punctatus*, and *B. venenosus brevis*. All these produced nitrites from nitrates, especially the *B. incanus*.

PLANT FORMATION.

WESTERN WISCONSIN AND NORTHEASTERN IOWA.

Clay Ridge Formation.—The plants of this formation are quite uniform throughout the entire region. Sometimes one or more species of trees may predominate. The flat areas naturally have different species of plants in part than the sunny and shady slopes. Of the trees the most conspicuous on the flat slopes are the oaks (*Quercus alba* and *Q. ruba* and *Q. tinctoria*). The shell bark hickory (*Carya alba*) is widely scattered but never in solid groves. Two poplars are common, (the *Populus tremuloides* and *P. grandidentata*). These species frequently form solid groves. Occasionally the basswood (*Tilia americana*) may be interspersed with the oaks and hickories, but this tree is usually found on the shady, moist slopes where the white and red oak, paper birch, two ironwoods (*Ostrya virginica* and *Carpinus caroliniana*) and pignut (*Carya amara*), two ashes (*Fraxinus sambucifolia* and *F. viridis*) also occur. The common *Pteris aquilina* is abundant everywhere forming a conspicuous feature of the woods wherever the timber has been removed. This fern soon occupies the ground, growing from two to three feet high. In such openings *Potentilla canadensis* and *Fragaria virginiana* are abundant. Formerly in such woods many strawberries were picked for home consumption. The *Apocynum cannabinum*, *Panicum macrocarpon*, *Bromus purgans*, *Calamagrostis canadensis*, *Phlox divaricata*, *Steironema ciliatum*, *Senecio aureus*, *Helianthus strumosus*, *Triosetum perfoliatum* and *Galium boreale*, *Agrimonia eupatoria*, *Geranium maculatum* occupy similar places.

In the shady woods *Panicum macrocarpon*, *Geranium maculatum*, *Anemonella thalictroides*, *Anemone nemorosa*, *Cypripedium pubescens* occur, the Phlox, Geranium, Panicum and Anemonella in greater abundance than the other species. The moccasin flower is widely scattered but never abundant.

Exposed Limestone Flats.—This formation at La Crosse is nearly 600 feet above the flood plain of the Mississippi. These areas do not cover much ground. In their younger stage they have the aspect of a typical prairie vegetation such as occurs in parts of Iowa. The most typical plant is the *Zygadenus elegans* and *Ranunculus rhomboideus*. On the limestone rocks there are large prostrate masses of *Juniperus virginiana*. The *Campanula rotundifolia*, *Arabis lyrata*, *Koeleria cristata*, *Aquilegia canadensis* are abundant. The most characteristic plant, however, is the Zygadenus which is found only on these flats.

The St. Croix Area.—Immediately below these limestone exposures is a sandy area in many places showing the St. Croix exposures where there has been much weathering. The soil is of a brownish color or it is blackish when it contains much humus. This area is in part treeless, but much of it consists of grassy covered slopes. The remainder is covered with a forest growth. Each of these areas will be considered separately.

Grassy Slopes.—The grassy slopes are made up in large part of grasses of a few species, among these *Bouteloua curtipendula*, *Andropogon scoparius*, and *Koeleria cristata*. Among the more prominent of the early flowering plants the *Viola pedatifida*, *V. pedata*, *Arabii lyrata*, *Phlox pilosa*, *Silene antirrhina*. Later *Ceanothus americanus*, *Delphinium azureum*, *Solidago rigida*, *S. nemoralis*, and *Rosa blanda*. These hills become quite dry late in summer and show little else than the dried blades of the grasses mentioned above.

Tree Covered Slopes.—The most conspicuous of the trees in the upper slopes are *Betula papyrifera*. On the shady slopes *Carpinus caroliniana*, *Ostrya virginica*, *Tilia americana*, *Juglans cinerea*. Lower slope, *Quercus rubra* and *Q. alba*, *Acer nigrum*, *A. rubra*, *Pinus strobus*. The hazel, *Corylus americana*, is common everywhere as are *Prunus americana*, *P. virginiana*, *Pyrus iowensis*. The herbaceous undergrowth consists of *Convolvulus spithamæus*, *Sanguinaria canadensis*, *Panicum macrocarpon*, *Dodecatheon media*, occasionally *Cerastium vulgatum*, *Cypripedium pubescens*, *Viola palmata* var. *Cucullata*, *V. pubescens*, *Geum album*, *Eatonia pennsylvanica*, *Geranium maculatum*, *Podophyllum peltatum*, *Convolvulus spithamæus*, *Asarum canadense*, *Hydrophyllum virginicum*, *Trillium erectum*, *Hepatica acutiloba*, *Anemone nemorosa*, *Arisæma triphyllum* are among the more important of the herbaceous plants. Altitude and situation determine the abundance of one or more of these plants. The Asarum, Trillium and

Arisæma, *Hydrophyllum appendiculatum* occuring in the rich black sandy humus near the bases of the bluffs. The *Acer nigrum* is common only along the west slopes of the Mississippi on the Wisconsin side and east slopes on the Minnesota side of the river. The *Acer nigrum*, however, reaches its greatest development in the Kickapoo valley and its tributaries. In the smaller valleys away from the Mississippi River the species is rare. Such is, however, not the case in northeastern Iowa. The *Acer rubrum* is an extremely rare species along the Mississippi River, only a few trees occurring and these not on the moist, sand-covered slopes as in the Kickapoo valley and its tributaries, but on the border of tamarack marshes. In the Kickapoo valley the moist covered slopes have the following assemblage of plants: *Acer spicatum*, *A. nigrum*, *A. rubrum*, *Diervillea trifida*, *Quercus rubra*, *Q. macrocarpa*, *Q. tinctoria*, *Taxus canadensis*, *Corylus rostrata*, *C. americana*, *Juglans cinerea*, *Tilia americana*, *Tsuga canadensis*, *Pinus strobus*, *Cypripedium pubescens*, *Asarum canadense*, *Trillium erectum*. The *Tsuga canadensis*, *Clintonia borealis*, *Epigæa repens*, *Coptri trifolia* and *Gaultheria procumbens* are very local. The rock in the Kickapoo valley is often on the surface and this largely accounts for the presence of the plants found here. The soil, too, is quite moist, much more so than the deeply eroded valleys along the Mississippi River.

The Lower Clay Slopes.—The kind of vegetation found on the lower slopes depends on the slope and altitude. Towards the upper portion of the region it is often more or less sandy; the further up, the more it has become impregnated with silica. The sunny slopes were in early times covered with both *Quercus macrcarpa* and *Q. tinctoria*, the former species predominating in Wisconsin and Minnesota while the *Q. macrocarpa* becomes more numerous in northeastern Iowa. *Ranunculus fasicularis*, *Cerastium vulgatum*, *Poa pratensis*, *Geum album*, *Silene stellata*, on the shady slopes *Quercus alba*, *Q. rubra*, *Panicum macrocarpon*, *Cypripedium pubescens*, *Poa pratensis*, *Pyrus iowensis*, *Prunus americana*, *P. virginiana*, *Corylus americana*. These slopes in early days were good agricultural lands and were cropped until they were no longer remunerative. They are now largely turned into pasture and meadow lands. On rich soil *Trifolium pratense*, *T.*

repens, *Agrostis alba*, *Poa pratensis*, *Poa compressa*, *Phleum pratense* grow admirably. *Poa pratense*, *Poa compressa* and *Agrostis alba* are excellent soil-binding grasses and hold the loose soil.

The Higher Alluvial Bottoms.—These occur along the streams in small attached areas. Many of the areas along the smaller streams, before they were brought under cultivation, were marshes. The soil is very rich, often consisting of three or four feet of black alluvial soil, brought down from the hills. These alluvial bottoms were covered quite uniformly with trees of the following species: *Acer saccharinum*, *Tilia americana*, *Ulmus americana*, *Populus monolifera*, *Quercus rubra*, *Carya amara*, *Fraxinus viridis*, and occasionally *Juglans nigra*. The *Arisæma triphyllum*, *Helianthus grosse-serratus*, and *Allium tricoccum*. The absence of *Betula nigra* and *Quercus bicolor* is to be noted.

The Mississippi Alluvium.— The alluvium of the Mississippi River consists of detached and broken sandy prairies in places, as on Goose and other larger islands which are not covered with water some years. Other portions are annually covered with water. The latter may again be divided into the wooded areas and small grassy islands and marshes. On the former the more conspicuous trees are *Acer saccharinum*, *Ulmus americana*, *Betula nigra*, *Populus Monifera* *Quercus bicolor*, scattered, *Fraxinus viridis* and occasionally *Quercus rubra*, and near the mouth of the Root River *Morus rubra* and *Gymnocladus dioica*.

The grassy islands and marshes contain as conspicuous plants *Lobelia cardinalis*, which form great red banks, *Dulictrium spatuaceum*, *Aster tradescanti*, *Poa scratina*, and *Boltonia asteroides*. A large assemblage of other plants will be considered in connection with the vegetation of marshes.

St. Croix Sandstone Ledges.— These ledges contain a large number of interesting plants. Many of the species are very local in their distribution. The kind of plants is largely determined by the altitudes and strata. The lower water-bearing strata consists of fine sandstone with a water-bearing strata from the base of which numerous springs arise. Along the upper slopes *Pinus stroba* and *Texus canadensis*, as well as *Betula lenta*, are conspicuous trees, while close to the springs *Alnus incana* occurs. The ferns are, however, the most interesting. We have here two species of *Phegoteris*, *P. dryopteris* and *P. polypodioides*, *Lycopodium lucidulum*, *Asplenium Filix-fœmina*, *Aspidium spinulosum* var. *dilatatum*, *Pellæa gracilis*, *Mitella diphylla*, and along the Kickapoo *Sullivantia ohionis*, *Clintonia borealis*, *Epigæa repens*, *Gaultheria procumbens*, *Circæa alpina*, *Cornus circinata*, *Aralia nudicaulis*, *A. racemosa*, *Acer spicatum*, *Œnothera fruticosa* and *Aquilegia canadensis*.

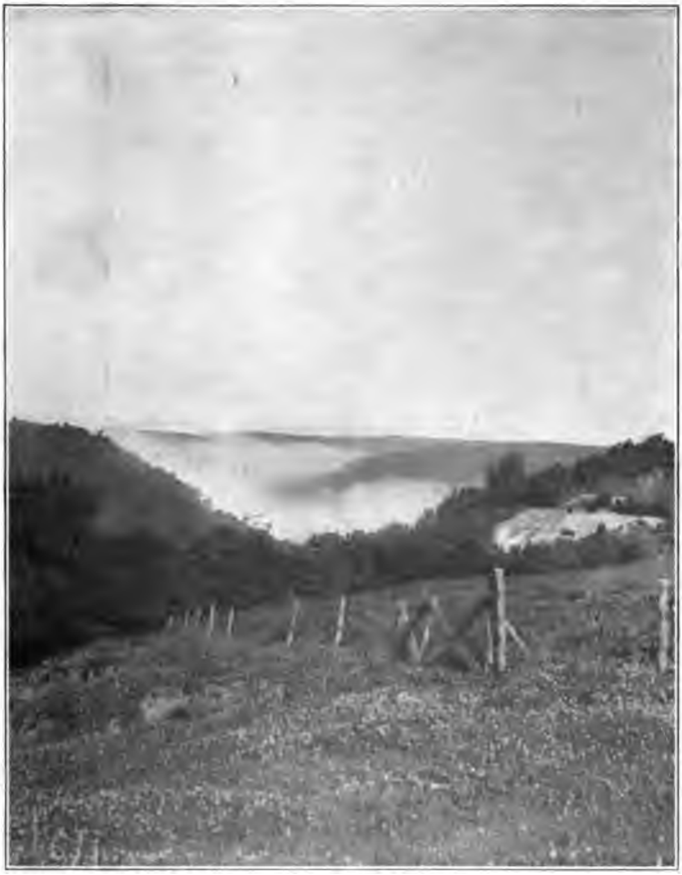

FIG. 11. Top of clay ridge formation with limestone outcrops. *Carpinus ostrya* and *Quercus* on side hills. Photograph by L. H. Pammel.

On the dry rock *Woodsia obtusa*, *W. ilvensis*, *Melica mutica*, *Poa nemoralis*, *Arabis lyrata*, *Campanula rotundifolia*, *Danthonia* *spicata* and *Vaccinium pennsylvanicum.* Some of these species, like *Vaccinium* and *Woodsia ilvensis*, are quite rare, the former, however, more widely distributed in the Kickapoo valley.

Rocky Limestone Talus.—This talus, as well as the vertical cliffs, contain an abundance of *Pellæa atropurpurea*, *Campanula rotundifolia*, and in moist situations *Dodecatheon media.* The *Camptosorus rhizophyllus* only occurs upon the talus near the base of the hills. *Arabis lyrata*, *Poa pratensis*, *Eatonia obtusata* and *Koeleria cristata* are common as well as *Cornus alternifolia* and *Rubus strigosus.* These two species, however, occur on sandy slopes.

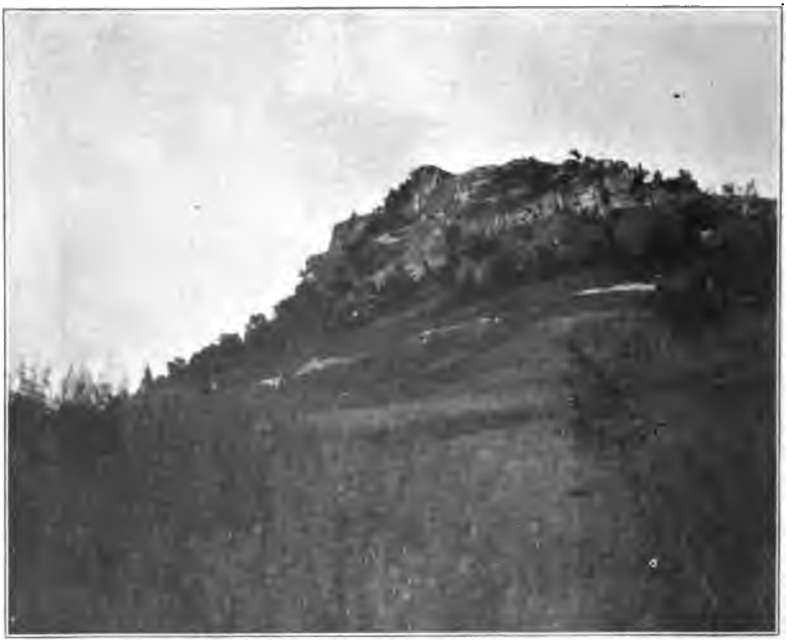

FIG. 12. St. Croix Area. Sandstone rock. Red Cedar in lower part, *Quercus tinctoria* and *Betula alba.* Photograph by Charlotte M. King.

Tamarack Swamps, Bogs and Marshes.—These have many plants in common. The bogs also have some plants in common with the marshes and tamarack swamps, but the number is small compared with those common to the tamarack swamp and the marsh.

The sphagnum bog has quite a number of plants peculiar to it. Sphagnum bogs in the region are very small and few in number. Some of these bogs have disappeared because of the filling up with drift material from the surrounding St. Croix sandstone outcrops. These areas, owing to the removal of the timber and cultivation of the soil, have washed greatly. In some cases these bogs have been filled with two or three feet of loose drift soil. We will therefore consider the plants under three heads—the tamarack swamp, sphagnum bog and the marsh.

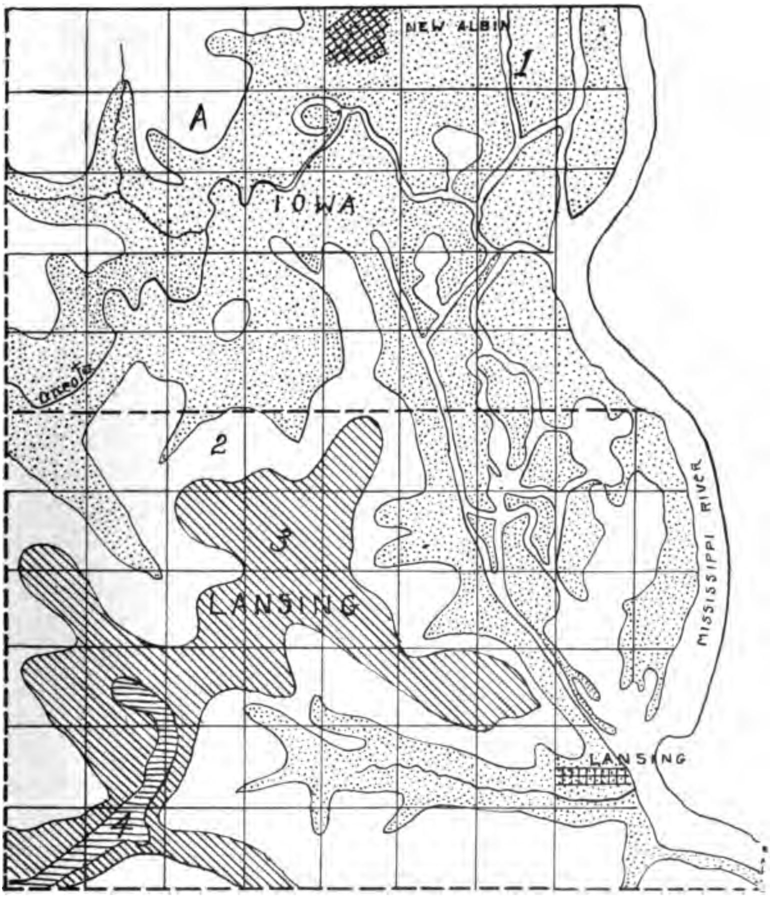

FIG. 13. Topographic Map of Northeastern Iowa. 1. St. Croix. 2. Oneota. 3. St. Peter. 4. Trenton after Calvin.

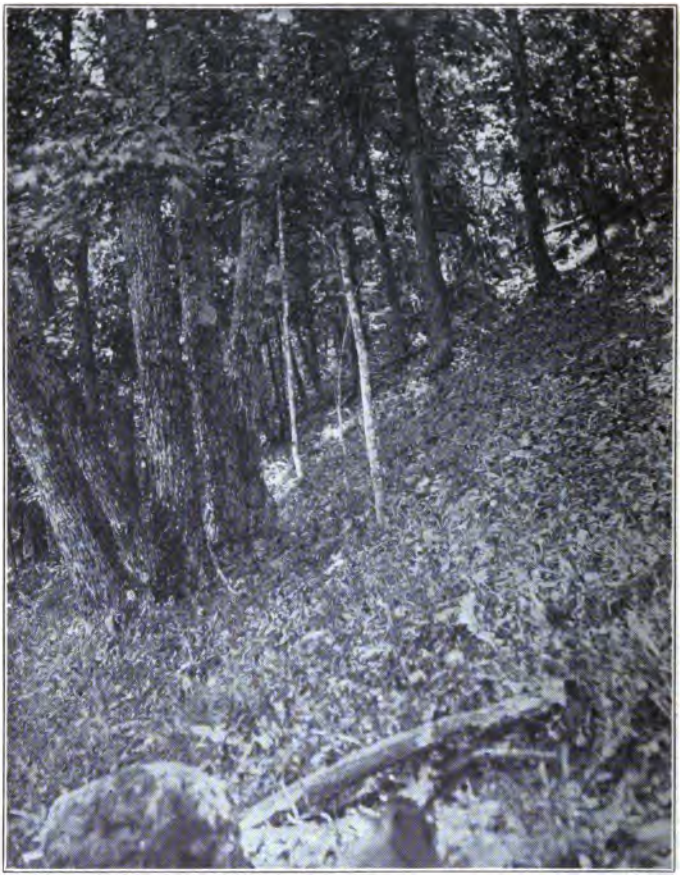

FIG. 14. St. Croix sandstone. *Tilia americana*, *Acer nigrum*, *Quercus tinctoria*, *Acer rubrum*, *Trillium grandiflorum*. Photograph by L. H. Pammel.

Tamarack Swamp.—The term here is used to designate those moist areas in which the *Larix americana* is the most characteristic tree. The Tamarack forms solid groves. No other tree seems to have adapted itself to these areas.* In the north, as in

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*For an account of the ecology of the vegetation of our northern woods see the paper of Conway MacMillan, "On the Occurrence of Stagnant Atolls in Central Minnesota." Minn. Bot. Stud. Geol. and Natural Hist. Surv. of Minn. Bull. 9: 2.
N. Whitford. Bot. Gazette, 31: 315.
Observations on the Distribution of Plants Along the Shore of Lake of the Woods. Bull. 9: 949.

the Cass Lake and Leech Lake country in Minnesota, *Abies balsamea*, *Picea nigra* and *Thuya occidentalis* are associated with the tamarack. The *Acer rubrum* is rare in the region close to the Mississippi and occurs only on the margin of the swamp. Of the shrubs the following are quite common: *Rhus venenata*, *Cornus stolonifera*, *Nemopanthes canadensis*, *Betula pumila*, *Ampelopsis quinquefolia*, *Viburnum opulus*, *Juniperus communis*, *Salix candida*, *S. discolor*, *S. rostrata* and *S. lucida*, the *Cypripedium*

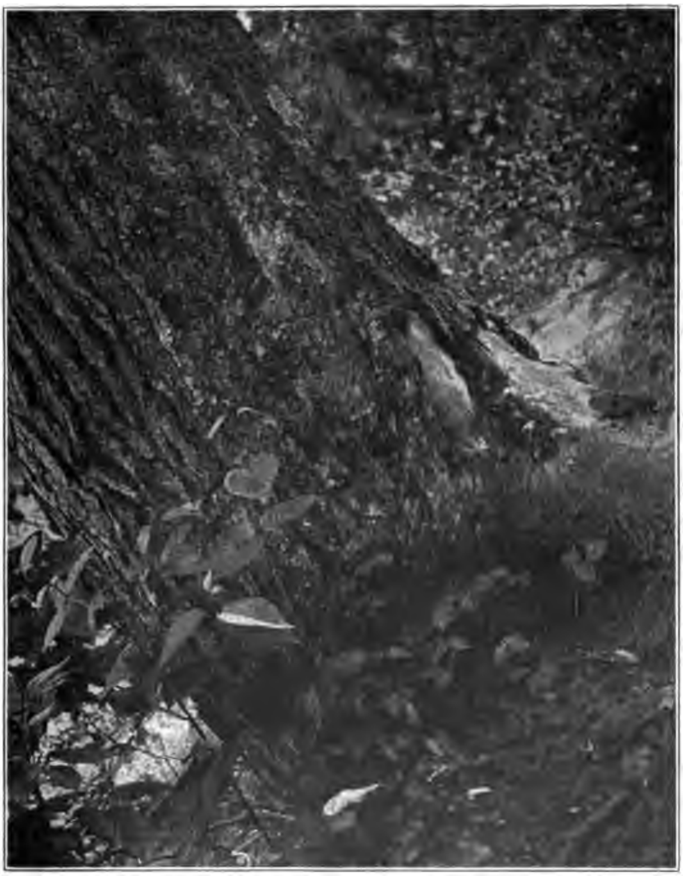

FIG. 15. Trunk of Hemlock (*Tsuga canadensis*), Bloomingdale, Wisconsin. Sandy loamy soil. *Cornus circinata*, *Fragaria vesca*, *Gaultheria procumbens*, *Epigæa repens*, *Dierrilla trifida*, *Circæa alpina*, *Pellæa gracilis*, *Smilacina bifolia* on the sandy, moist rock; also *Acer spicatum*. Photograph by L. H. Pammel.

spectabile, *C. arietinum*, *Caltha palustris*, *Osmunda cinnamomea*, *O. regalis*, *Aspidium cristatum*, *A. noveboracense*, *Pyrola rotundifolia*, *Valeriana edulis*, *Rubus triflorus*, *Potentilla palustris*, *Coptis trifolia* and *Smilacina trifolia*. The *Saxifraga pennsylvanica*, *Thalictrum purpurascens*, *Lysimachia thrysiflora* and *Caltha palustris* are widely distributed.

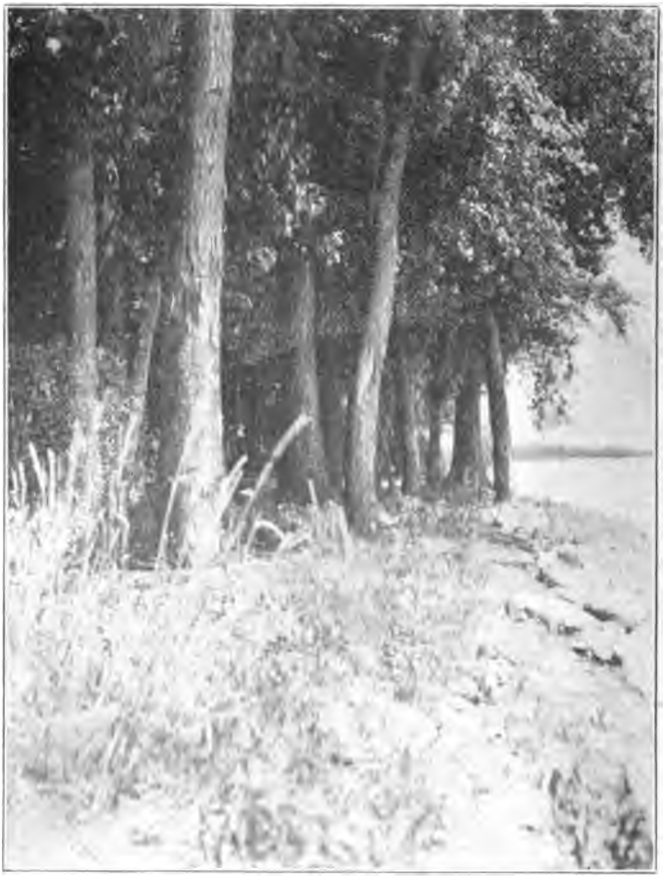

FIG. 16. Low sandy alluvium along the Mississippi River near La Crosse. *Acer saccharinum*, *Populus monilifera*, *Fraximus viridis*, *Quercus bicolor*, *Aster Tradescanti*, *Leersia virginica*. Photograph by L. H. Pammel.

Sphagnum Bogs.—The sphagnum is a dominant plant. Equally common is the *Menyanthes trifolia*, which blooms during the month of July. *Sarracenia purpurea* is found nowhere else in the region.

It occurs not only over the bog, but on the margin. Other rare plants in the region are the following: *Rhynchospora alba*, *Pogonia ophioglossoides*, *Calopogon pulchellus*, *Eriophorus virginicum*, *Salix candida*, *Betula pumila*, *Drosera rotundifolia*, *Lobelia kalmii*, *Bidens beckii*, *Cicuta bulbifera*, *Cnicus miticus*, *Parnassia carolinians*, *Osmunda regalis*, *O. cinnamomea*. *Pyrola rotundifolia* and *P. elliptica* are found on the shores or on the small hummocks found in the bogs where sufficient soil has accumulated.

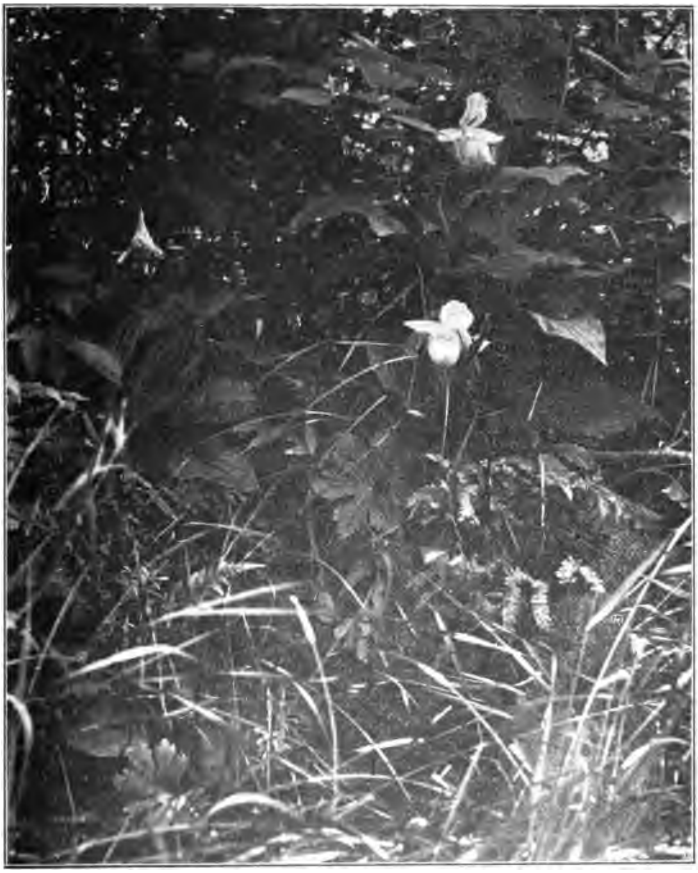

FIG. 17. *Cypripedium spectabile* in Tamarack marsh with *Ampelopsis quinquefolia*, *Cornus stolonifera*, *Larix americana*, *Osmunda regalis* on the ledges of the swamp in sandy wet soil, along with *Osmunda cinnamomea* and an occasional *Acer rubrum*. Photograph by L. H. Pammel.

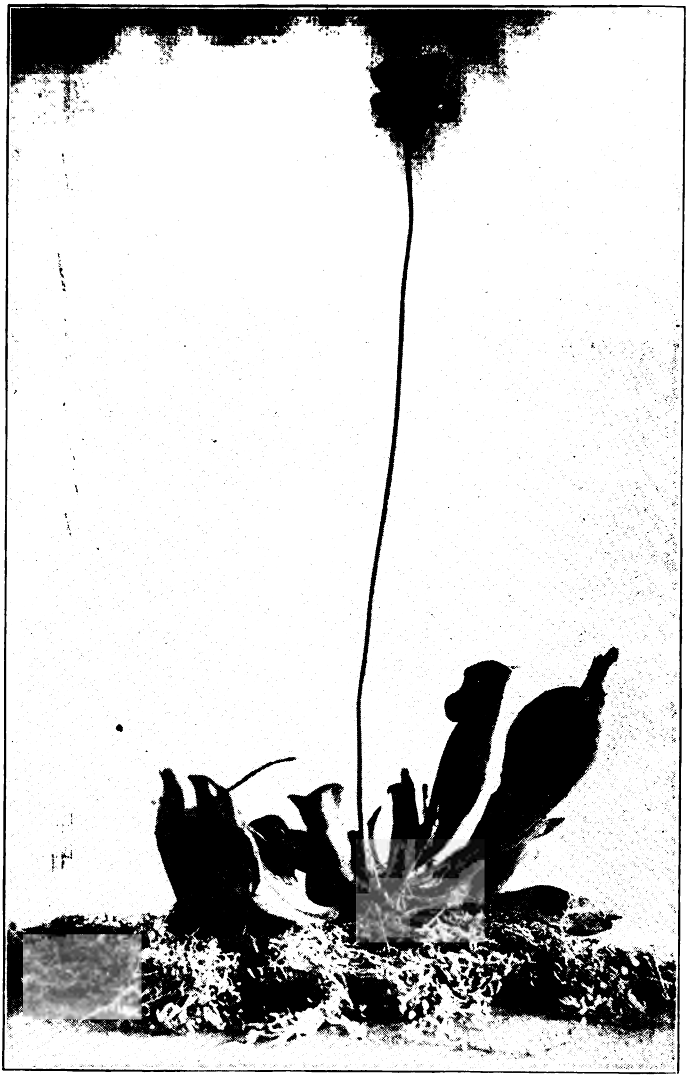

FIG. 18. *Sarracenia purpurea* occurring with *Pogonia*, *Drosera*, and Sphagnum moss in bogs. Photograph by Charlotte M. King.

Wet Marshes.—The marshes are drier than the bogs, still they contain considerable moisture and are wet during the entire year. From these marshes come perennial springs. Where these are of sufficient size they form small streams. These are lined with several species of willow, like *Salix discolor* and *S. richardsoni*. The *S. candida* and *S. lucida* are confined to the marshes in proximity to the tamarack swamp and sphagnum bog. *Alnus incana* and *Cornus stolonifera* are characteristic shrubs. The *Viburnum opulus* and *Betula pumila* are more restricted in their distribution. *Saxifraga pennsylvanica*, *Thalictrum purpurascens*, *Viola blanda*, *Iris versicolor*, *Glyceria nervata*, *G. arundinaceæ*, *Parnassia caroliniana*, *Lilium canadense*, *Pedicularis lanceolata*, *Lycopus sinuatus*, *Mentha canadensis*, *Stachys palustris*, *Gentiana crinita*, *G. andrewsii*,

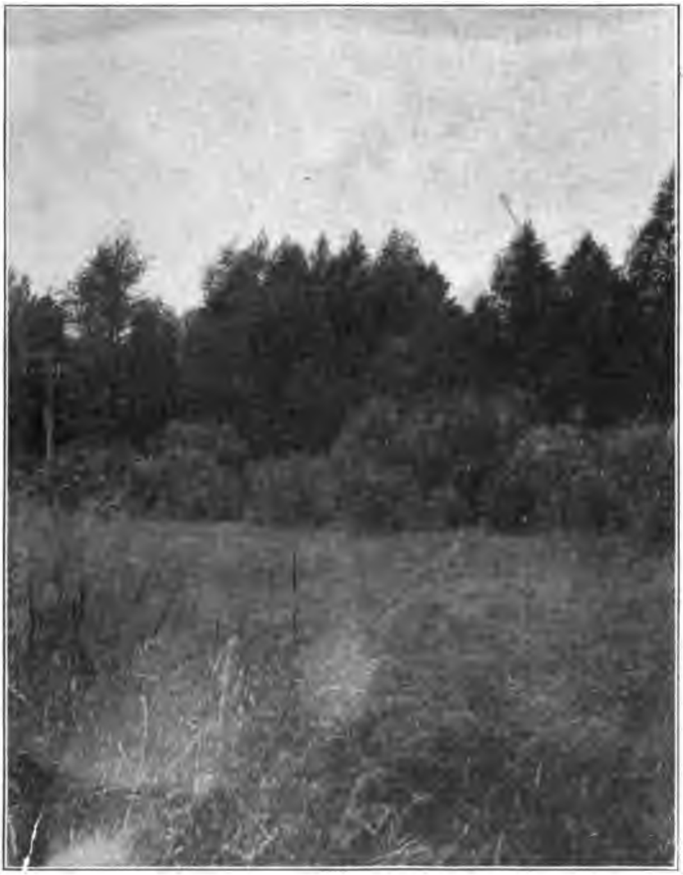

FIG. 19. Edge of Tamarack Swamp in La Crosse County, Wisconsin. *Phragmites, Salix lucida and Cornus stolonifera.* Photograph by L. H. Pammel.

Castilleia coccinea, *Heracleum lanatum*, *Valeriana edulis*, *Cnicus muticus*, *Archangelica atropurpurea*, *Conium maculatum*, *Cardamine rhomboidea* and *Bromus kalmii* are common plants of general distribution in these marshes. The *Cypripedium candidum*, *Caltha palustris*, *Viola blanda*, *V. carina* var. *muhlenbergii* and *Symplocarpus fœtidus* are local plants found in proximity to springs.

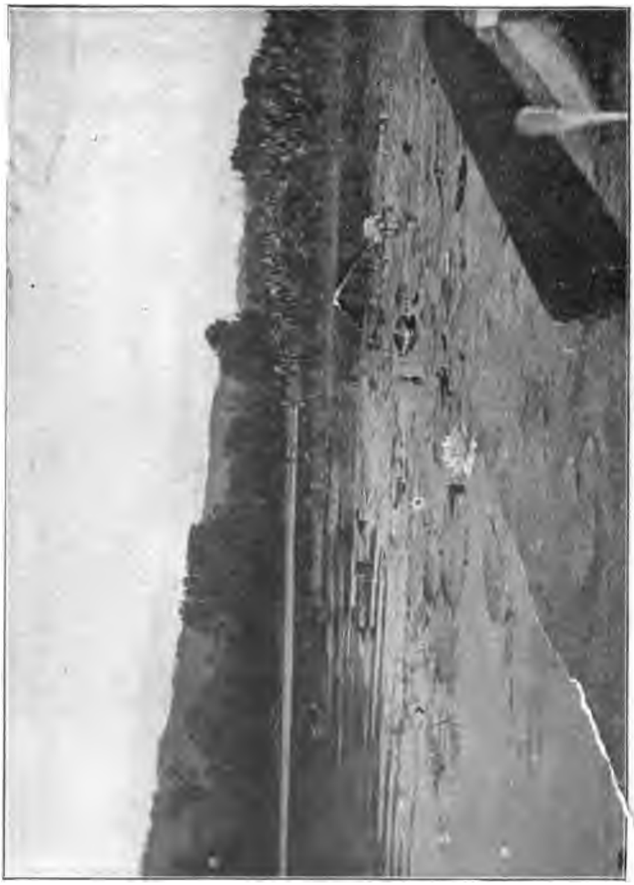

FIG. 20. *Nymphæa tuberosa* in slow-running streams and sloughs near Lansing, Iowa. Photograph by Charlotte M. King.

Alluvial Marshes.—These marshes are often very wet in the spring and influenced by standing water in the spring and early summer. These marshes border the larger streams. They cover much of the area of the Mississippi and Black rivers. Close to the shore lines of the "sloughs" the *Zizania aquatica*, *Scirpus atrovirens*, *Leersia virginica*, *Dulichium spathaceum*, *Boltonia asteroides*, *Aster tradescanti*, *Sparganium eurycarpum*, *S. simplex*, *Pontederia cordata*, *Alisma plantago*, *Sagittaria variabilis*, *Heteranthera graminea*, *Acorus calamus*, *Typha latifolia*, *Mimulus ringens*, *Lobelia cardinalis*, *Panicum crus-galli*, *Ilysanthus riparia*, *Hemicarpha subsquarrosa* and *Lythrum elatum*. The Lythrum develops ærenchyma along the lower part of the stem, its function being to protect the plant when it becomes immersed.

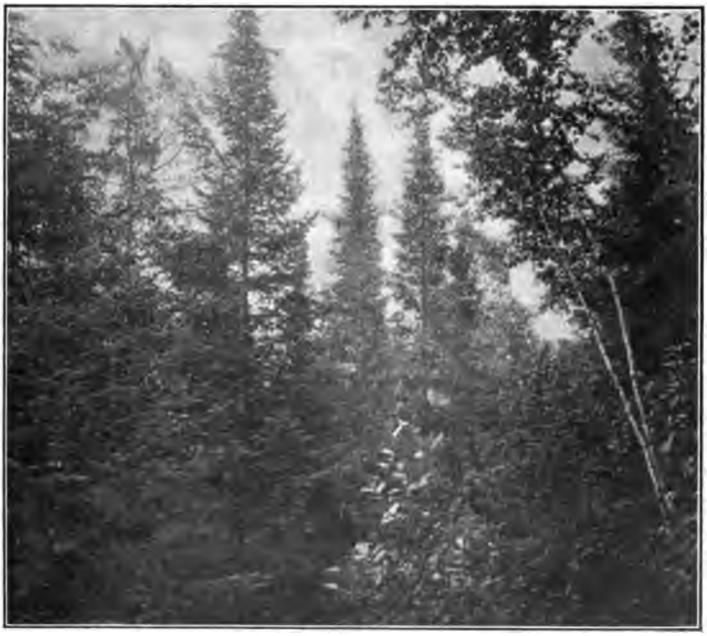

FIG. 21. Balsam Fir (*Abies balsamea*), *Betula papyrifera*, *Pyrus arbutifolia*, *Corylus rostrata*, *Circæa alpina*, *Quercus rubra*, *Acer spicatum*, *Viburnum opulus*. In open places, *Aconitum uncinatum*. Photograph by L. H. Pammel.

Aquatic Vegetation.—The *Nuphar advena* is widely distributed in ponds and sloughs. The *Nymphea tuberosa* occurs in the small lakes and slow-running sloughs. The *Nelumbo lutea* occurs in a few places also in slow-running water. The *Elodea canadensis* and *Vallisneria spiralis* are widely distributed in ponds and slow-running streams. *Ranunculus multifidus* and *R. aquatilis* var. *trichophyllus*, *Lemna trisulca*, and *L. minor* as well as *Potamogeton* *heterophyllus*, *P. natans* and other species are common. The *Mimulus jamesii* is local.

Development of the Swamp.—The region here is peculiar in that there is no evidence of glacial action in the formation of lakes. Inland lakes, or more properly ponds, are of rare occurrence in the region of Minnesota and southwestern and northeastern Iowa under consideration. Away from the streams only a very small number of ponds or lakes occur. The one described here occurs in State Road Coulé and is of comparatively recent origin. The present small creek in State Coulé once had its course along the west side of the bluffs, but by the accumulation of sedimentary material a few miles south cut through an alluvial flood plain, the water sinking away in large part in the loose sandy soil some two miles south of the mouth of the small valley, joining, however, the old channel in time of high water. The accumulation of water from springs at the base of the hills forms a small lake with a marsh of some size at the lower end. Around this lake there occur *Scirpus lacustris*, *Lemna major*, *L. trisulca*, *Elodea canadensis*, *Potamogeton natans* and *Hippuris vulgaris* and *Ranunculus aquatilis* var. *tricophyllus*. The *Spirogyra*, *Zygnema* and *Desmids* are the most important of the hydrophytic plants. On the muddy shore lines *Eleocharis acicularis*, and *E. palustris* and further out the *Acorus calamus*, *Caltha palustris*, and *Symplocarpus fœtidus*, *Iris versicolor* and *Phyragmites communis* form the border of the lake. The ground surrounding the pond is elevated and the vegetation here consists largely of *Glyceria nervata*, *G. arundinacea*, *Phalaris arundinacea*, *Castilleia coccinea*, *Burnus kalmii* and *Campanula aparinoides*, but especially of sedges. The *Scirpus lacustris* and other aquatic plants no doubt were the forerunners of the present marsh vegetation surrounding the pond. *Nuphar*, *Nymphæa*, and *Nelumbo*, aquatic plants of the Mississippi, do not occur. Nicholas Whitford,[1] in describing the development of glacial swamps in northern Michigan, states as follows: "Most swamps start as ponds or lakes, in which water-lilies and other pond plants dominate. On the borders of the pond sedges appear; these, by their decay, build up a soil, and thus prepare the way for the next zone, the Cassandra-sphagnum vegetation. The sedges encroach farther on the original lake. The Cassandra-sphagnum zone makes conditions possible for a tamarack-spruce zone. Thus each successive zone is pushed farther and farther toward the center. Finally the lily center disappears, and then successively the sedge and Cassandra zones, until a tamarack forest may come to occupy the whole territory."

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[1] Bot. Gazette, 31: 313.

The bottom of the pond consisted of peat mixture lying on a brown sandy soil. The water is derived from perennial springs. The soil is not typical peat but a mixture of considerable humus and some sand. Two other typical swamp areas may be considered. One, a tamarack marsh in the town of Campbell. This was formed by the accumulation of sand and alluvium at the mouth of the present marsh, where it joins the La Crosse River.

During times of high water this area was filled with water in which aquatic plants probably like *Nuphar*, *Nymphæa*, *Scirpus*, and *Elocharis* formed the principal vegetation. These by decay formed humus which gradually filled the lake and thus gave rise to a bog. As the filling process continued the *Larix americana* made their appearance. Prof. L. H. Harvey[1] in his paper on a study of the physiographic ecology of Mt. Katadin finds in his studies of the sphagnum bog society that the sphagnum advances from the edge, finally the open space is spanned, sufficient soil is formed to permit *Scheuchzeria palustris* to grow; and with more soil *Sarracenia purpurea*, *Vaccinium macrocarpon*, *Smilacina trifolia*. With drier conditions *Eriophorum* and *Carex trisperma* are important constituents. These are followed by *Cassandra calyculata*, *Kalmia angustifolia*, and *K. glauca*. In our bogs we find neither *Kalmia* nor *Smilacina trifolia*. The *Smilacina* is an abundant constituent of the tamarack swamp. The *Vaccinium*, however, is common as *Eriophorum*. The *Picea nigra* is given as the pioneer for the Mt. Katadin bog. Whitford[2] speaks of a tamarack-spruce zone following the Cassandra. Coulter[3] in a paper, "An Ecological Comparison of Some Typical Swamp Areas," refers to the formation of the bogs on North Manitou Island as follows:

"The peat mosses which thrive so luxuriantly in poorly drained conditions are among the pioneer forms concerned in this process, while the cranberry (*Vaccinium macrocarpon*) quickly follows and soon forms a foothold for the leather-leaf (*Cassandra calyculata*) and allied forms.

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[1] The University of Maine Studies, 5: 43.

[2] l. c. 314.

[3] Rept. Mo. Bot. Garden, 15: 43.

"On the land margin the tamaracks and spruces are closely crowding on the shrubs, and back of these, the hemlock-maple-beech forest is encroaching on the conifers."

"The zonal distribution of plants is well illustrated in these tamarack swamps. Within the surrounding forest of maple, beech, and hemlock, the real swamp area is found. The surface of the peaty soil is covered with sphagnum and this zone is dominated by *Larix americana* and *Picea nigra*."

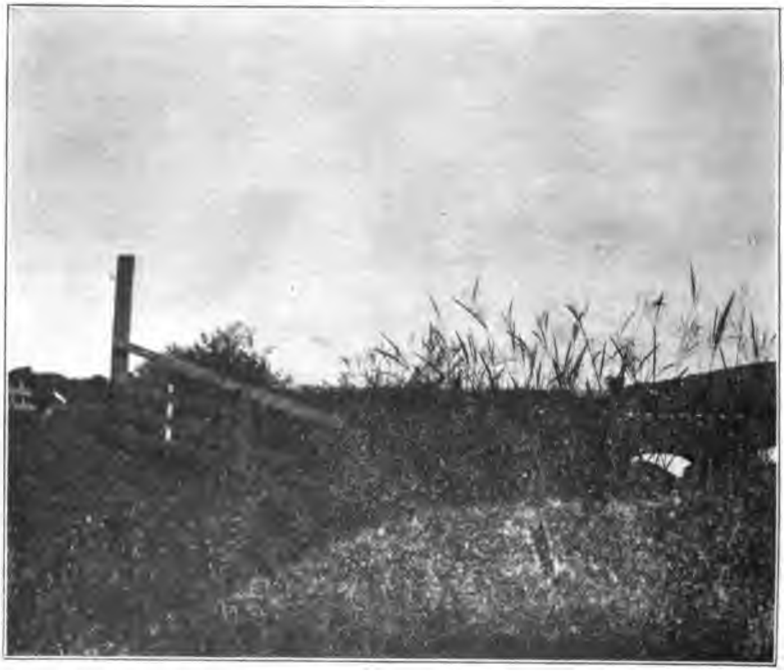

FIG. 22. *Zizania aquatica* on border of wet marsh. Photograph by Charlotte M. King.

The spruce is absent in western Wisconsin because of climatic conditions, its range being more northward. There are, however, isolated small spruce swamps forty or fifty miles eastward. The arbor vitæ mentioned elsewhere as occurring mixed with tamarack and balsam in northern Minnesota is also more northern in its distribution. However, eastward the species occurs on the St. Croix sandstone along the Wisconsin River associated with *Pinus resinosa*, *P. strobus*, and *Pyrus americana*. Trees frequently follow the courses of streams where they obtain a meager foothold. This is true of the *Quercus bicolor*. The *Acer rubrum*, which to the north and east occurs not only along streams but associated with the white and Norway pine, is in its most western part in Wisconsin found on the border of the tamarack swamp. This tamarack swamp is not only too wet, but the soil condition, probably because of its acidity, is unsuited for the *Acer saccharinum*, *Ulmus americana* and the other alluvial types; hence the line of tension is not so great, permitting the red maple to get a foothold. The tamarack, because of its wide adaptability, occupies a place that no other tree so readily occupies in these marshes. Under cultivation the tamarack succeeds admirably in clay soil everywhere in the region.

These bogs, however, did not form generally in the region. This particular *Larix* swamp and bog lies between low hills. The strata below consists of a fine sand which is highly retentive of moisture and hence made the conditions favorable for the formation of a bog. Adjoining the swamp and in numerous places along the smaller streams are wet marshes which are frequently more or less sloping or but a few feet above the flood plain of the streams and hence, during freshets, covered with water. The sphagnum bog, before the removal of the timber above it, received clear water, but since the cultivation of much of the land above it has become covered with sand to such an extent that its characteristic plants have been obliterated. The *Menyanthes trifolia* is making a vain attempt to persist, *Sarracenia*, *Drocera*, *Eleocharis* and *Pogonia* having entirely disappeared. The *Larix americana* is not common in La Crosse county. The seed was probably carried to the La Crosse River from the country to the north. A second tamarack marsh in La Crosse county occurs in Mormon Coulé, some fourteen miles south. There is no longer a sphagnum bog surrounding or in close proximity to the tamarack grove. The coulé at this point is about one mile wide. The flat area here is wider than at any other point along the creek. The stream is small. A mile below the valley narrows. The soil in proximity to the tamarack marsh is very rich. All evidence seems to show that we had here an ancient lake which has to a large extent been drained. The region surrounding the grove is still very swampy, but there is no evidence anywhere of a typical sphagnum bog with its accompanying plants like *Sarracenia purpurea*, *Drocera rotundifolia* and *Pogonia*. However, *Salix candida*, *S. lucida*, *S. discolor* and *Aspidium noveboracense* are abundant. The vegetation here is similar to that of the first area here considered. The tamarack swamp is a typical forest island; the seeds were undoubtedly carried by the wind from the La Crosse valley. These marshes are numerously provided with springs and, where there is sufficient fall, form small runs along whose courses the *Salix rostrata*, *Alnus incana* and *Cornus stolonifera* are abundant. As the drainage became more perfect the elevated flat areas bordering on the swamp became covered with shrubs and trees, finally culminating in a growth of trees like *Populus tremiloides*, *Tilia americana*, *Ulmus americana*, *Fraxinus* and *Quercus rubra*.

The Development of Plants on the St. Croix Sandstone.—Some of the slopes are bare of tree forms, as they have been for ages. The location of the slope and altitude are, however, important factors. The bare slopes are peculiar to the region adjacent to the Mississippi River both on the Wisconsin and Minnesota sides of the river. Away from the river these "bald" areas are smaller. The north slopes are generally covered with a tree growth. East and south exposures, as well as some of the southwest exposures, are treeless. Prof. T. H. Macbride[1] accounts for it in this way:—

"North slopes in our latitudes are for only a few months exposed to the sun at all; eastern slopes have the advantage of the dewfall and the coolness of the night before meeting the heat of the morning sun, while the south slopes lie all day long beneath the hottest rays, and the west endures the heat of the afternoon. In the second place, our prevailing winds being from the west, the greatest amount of snow is always lodged on eastern or southeastern slopes. Of all these conclusions Allamakee county shows us a remarkable confirmatory illustration. The observer has but to drive across the country anywhere to discover that the southwestern sides of all the rounded knolls and hills are bare; always have been."

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[1] Rept. Iowa Geol. Survey, 4: 116.

There has been a remarkable change in the character of the vegetation of these hills within the memory of man. The absence of trees here has been in part accounted for by the prairie fire. It is, however, only one of the causes. Formerly "prairie fires," as they are called, could be seen in all directions during the month of April. They would burn the entire areas except the shaded north and northeast slopes where the snow remained longer and the soil and dead grass was too moist for a good blaze. Since the checking of these fires forest growth has expanded. It has gradually encroached upon some of the bare slopes. In a paper on the forest condition in western Wisconsin the following statement was made:[1] "During the past thirty years some important changes have taken place in the growth of timber along the river. The pioneer settler found little timber on the hills except those with a northern slope. The timber standing on the sunny sides was usually poor in quality, owing to numerous fires. Now these lands are mostly fenced, and fires are kept out, at least by the more enterprising farmers. The bleak hills are being rapidly covered with a forest growth.

"It is not an uncommon thing to observe patches of Hazel (*Corylus americana*, Walt.) beyond the outskirts of the timber; here, in the course of a few years, will be found Oaks, Birches, Hickories, and Poplars. The humus formed where Hazel grows is extremely rich and fertile, and I doubt whether trees could cover our treeless hills very fast without its help."

Since making this statement the region has been visited several times and I have not altered my views. The mesophytic forest has extended and encroached on the grass covered Saint Croix area.

It is evident that such species as *Andropogon scoparius*, *Delphinium azureum*, *Viola pedatifida*, *Lithospermum hirtum* and *Castilleia sessilifolia* are the forerunners for a mesophytic shrub growth, the most important of all these plants being *Rhus glabra*, *Ceanothus americanus*, which appears with the *Andropogon* and *Viola*. The *Rosa blanda* and *Ceanothus* are widely scattered where the *Rhus* forms copses. The *Corylus* shows a long step in advance of the *Rhus;* the collection of a good humus and an abundance of loose soil put it in a good condition for the growth of *Betula*

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[1] Garden and Forest, 4: 462.

papyrifera, *Prunus americana*, and *Quercus tinctoria*. It is only on the very dry slopes that *Quercus macrocarpa* appears. The older the forest becomes and the more humus and decayed organic matter is found, the more favorable the region becomes for the *Quercus rubra* and *Q. alba*. Occasionally these outlying situations, especially the more moist and lower hill slopes, contain *Pinus strobus*, a tree limited along the Mississippi from La Crosse southward to these sandstone rocks. However, in the northern part of this and Trempleau counties the species is common in sandy oak openings. Eastward in the Kickapoo valley it occurs not only in the moister valleys but also along the sandy St. Peter's sandstone ridges. The line of tension between the white pine and deciduous trees is so great along the St. Croix sandstone that it occupies somewhat inaccessible areas.

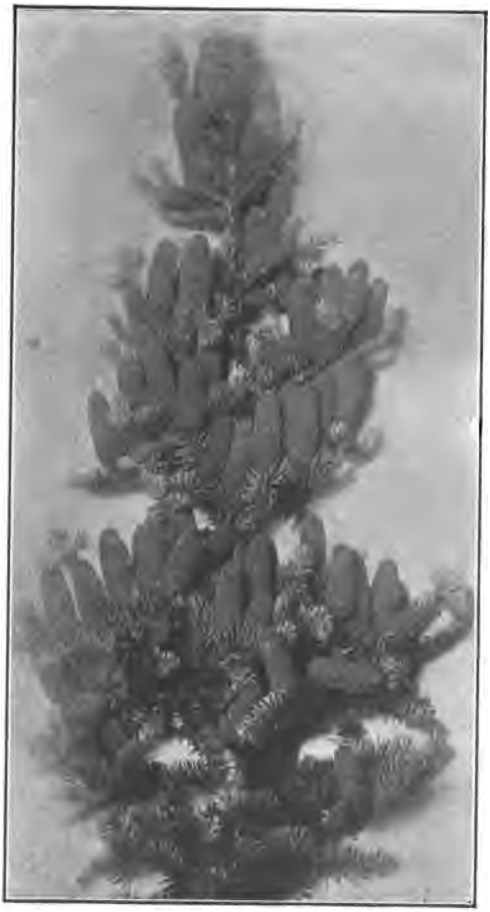

FIG. 23. Upper part of tree of *Abies balsamea* heavily loaded with cones. Photograph by L. H. Pammel.

Yellow River Region in Allamakee County.—The area about Myron must be considered separately. With Mr. Ellison Orr and Mr. D. O. Wilson, a day was spent early this summer in an investigation of this interesting region. The area here considered is on the north slope of a hill, with the Yellow

River flowing at its base. The Yellow River is a stream of considerable size, having its source from several streams from one-half to three-quarters of a mile above the place where the Balsam Fir occurs. Temperature records taken of the soil one inch down at random indicated that the soil was much cooler than that of the surrounding woody hills and bluffs. The limestone rock is extremely porous and all through it are caverns of various sizes. From these caverns during the summer cold air is constantly issuing. At one point where the rock was covered with mosses, consisting of *Hypnum tamariscinum* and *Anomodon minor*, the temperature was 46°F. The highest temperature found in open places was 63°, at a depth of one inch. At other points the temperature varied from 56° to 60°, showing that one of the most important factors in connection with the boreal plants developed here is the temperature. The temperature of the air was 75°.

The stretch of Balsam Fir woods extends from about one-half to three-quarters of a mile on the north slope of a hill. The Balsam Fir, the White Pine[1], *Pyrus arbutifolia*, *Corylus rostrata*, *Diervilla trifida*, *Betula papyrifera*, *Lonicera glauca*, *Aralia quinquefolia*, *A. racemosa*, *Bromus purgans*, *Poa nemoralis*, *Campanula rotundifolia*, *Aquilegia canadensis*, *Hydrophyllum virginicum*, *Taxus canadensis*, *Sambucus racemosa*, *Phegopteris calcarea*, *Acer spicatum*, *Aconitum uncinatum*, *Viola blanda*, *Saxifraga pennsylvanica* and *Arabis lyrata* were distributed throughout the region. The *Poa nemoralis*, *Arabis lyrata* and *Campanula americana* occurred upon the limestone rocks with little soil. They occurred with numerous species of lichens, of which the following are prominent: *Buellia albo-atra*, *Lecanora privigna*, *L. calcarea* var. *contorta*, and *L. muralis* var. *versicolor*. The *Polypodium vulgare*, *Circæa alpina* and *Cypripedium pubescens* were more or less local. Most of the limestone rock has become covered with vegetation. It is only in the drier places that the *Arabis lyrata* thrives. The *Saxifraga pennsylvanica*, *Viola blanda* and *Bromus kalmii* occur in the moister places.

Flora of the Wisconsin Drift.—There are three types of plant formations on the Wisconsin drift. First, the flora of the larger valleys of streams, second, the flora of the bogs and marshes, and third, of the prairies. The first has been considered in connection with the flora found along the Des Moines, the Iowa and other streams.

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[1] Pinus strobus.

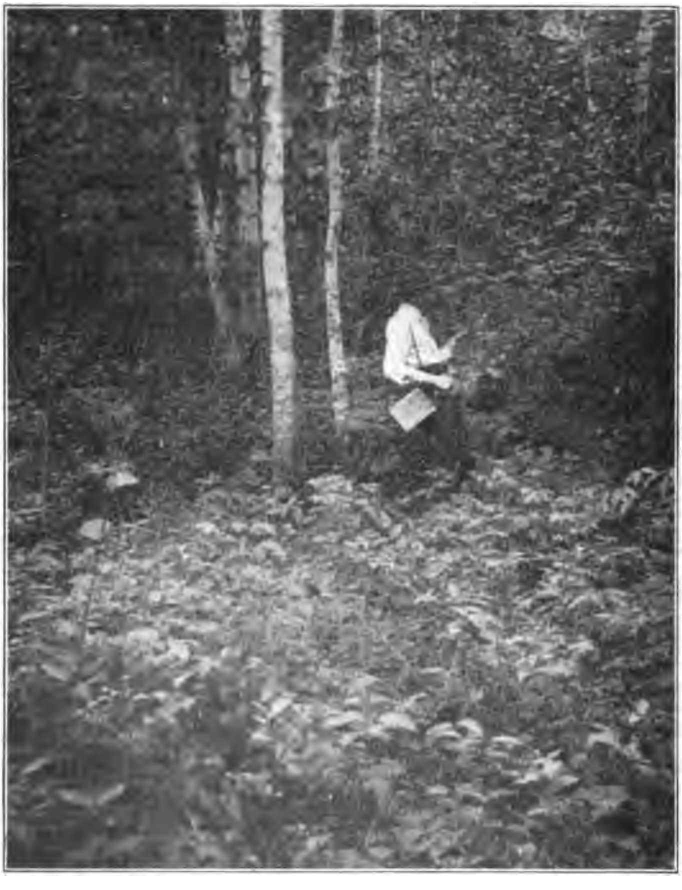

FIG. 24. In the interior of a group of White Birches, *Betula papyrifera* and *Corylus rostrata*, *Pyrus arbutifolia*, covering the ground in the foreground. Photograph by L. H. Pammel.

In Hamilton, Story and Wright counties, ancient lake beds are numerous, but nowhere do they present as many typical boreal plants as in Cerro Gordo, Hancock and Worth counties. In Hamilton county the old Mud Lake was a shallow body of water covering about fourteen hundred acres. The depth of the water was only a few feet in most places, varying with the amount of rainfall. The marginal flora of the lake consisted largely of *Scirpus lacustris*, *Typha latifolia*, *Zizania aquatica*, and *Nymphæa tuberosa*. On the margin, in marshy ground, *Iris versicolor*, *Scirpus atrovirens*, *Eleocharis palustris* formed the most characteristic plants before its drainage.

Generally speaking, the flora of the Wisconsin drift contains the characteristic prairie vegetation not unlike that of other western prairie states. The several species of *Liatris*, its broad waving fields of *Andropogon* accompanied by *Phlox pilosa*, *Panicum scribnerianum*, *P. virgatum*, *Vicia americana*, *Geranium maculatum*, *Rosa blanda* var. *arkansana*, *Ceanothus americanus*, *Echinacea purpurea*, *Lithospermum canescens*, *L. angustifolius*, *Viola palmata* var. *cucullata*, *V. pedata*, *Castilleia sessilifolia*, *Astragalus caryocarpus*, *Stipa spartea*, *Ceanothus ovatus*, and *Delphinium azureum*.

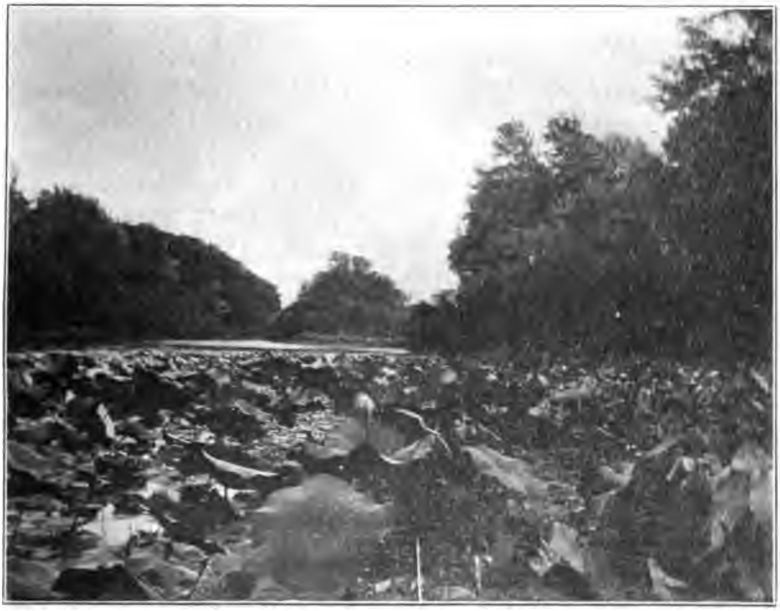

FIG. 25. *Nelumbo*, Mississippi River, near Redwing, Wisconsin side. Photograph by J. E. Guthrie.

The Flora of the Bogs of Cerro Gordo and Worth Counties—These bogs are interesting from a phytogeographical standpoint. We have here representatives of a flora common in Minnesota to the north and the bogs of western Wisconsin. Many species have, however, disappeared in their immigration southward and northward. The conditions favorable for the development of these glacial plants have gradually disappeared, owing to the absence of proper soil and temperature conditions. The long and hot summers greatly increased the heat of the soil and water in which these plants thrive, hence their extermination. A few illustrations will suffice. The *Cnicus muticus*, though common in these bogs, occurs more commonly in Wisconsin marshes that are fairly dry during the latter part of the season. The same may be said of *Parnassia caroliniana*, *Chelone glabra*, *Thalictrum purpurascens* and *Pedicularis lanceolata*. The *Salix candida*, *Lobelia kalmii* and *Circuta bulbifera* are equally common in the bogs of western Wisconsin and in Worth county. The *Salix richardsonii* and *S. discolor* are found throughout the Wisconsin drift area. The *Hierochloe borealis* hardly reaches the southern end of the Wisconsin drift as it only reaches as far south as Marshall and Hamilton counties. This grass, however, can hardly be classed as a real bog species as it is usually found on moist drift soils further northward. A hasty survey certainly shows that the Wisconsin drift has influenced in a marked manner the flora of northern central Iowa.

A brief list of the plants shows that the sphagnum which constitutes the bulk of the vegetation in the bogs of Wisconsin is entirely lacking in Worth and Cerro Gordo counties, and in place we find *Hypnums*. The bogs, however, contain a number of most interesting northern plants, among them *Bidens beckii*, *Cnicus muticus*, *Gentiana crinita*, *G. quinqueflora*, *G. andrewsii*, *Parnassia caroliniana*, *Cicuta bulbifera*, *Bromus kalmii*, *Thalictrum purpurascens*, *Salix discolor*, *S. richardsonii*, *S. candida*. The *Salix richardsonii* and *Populus tremuloides* are quite conspicuous shrubs. Owing to the deposit of soil through cultivation these bogs are beginning to "dry up," as the common expression is. Scattered throughout the bogs are small groups of *Populus tremuloides* which in course of time will give rise to a mesophytic forest. In fact, the course of the formation of the forest here is very

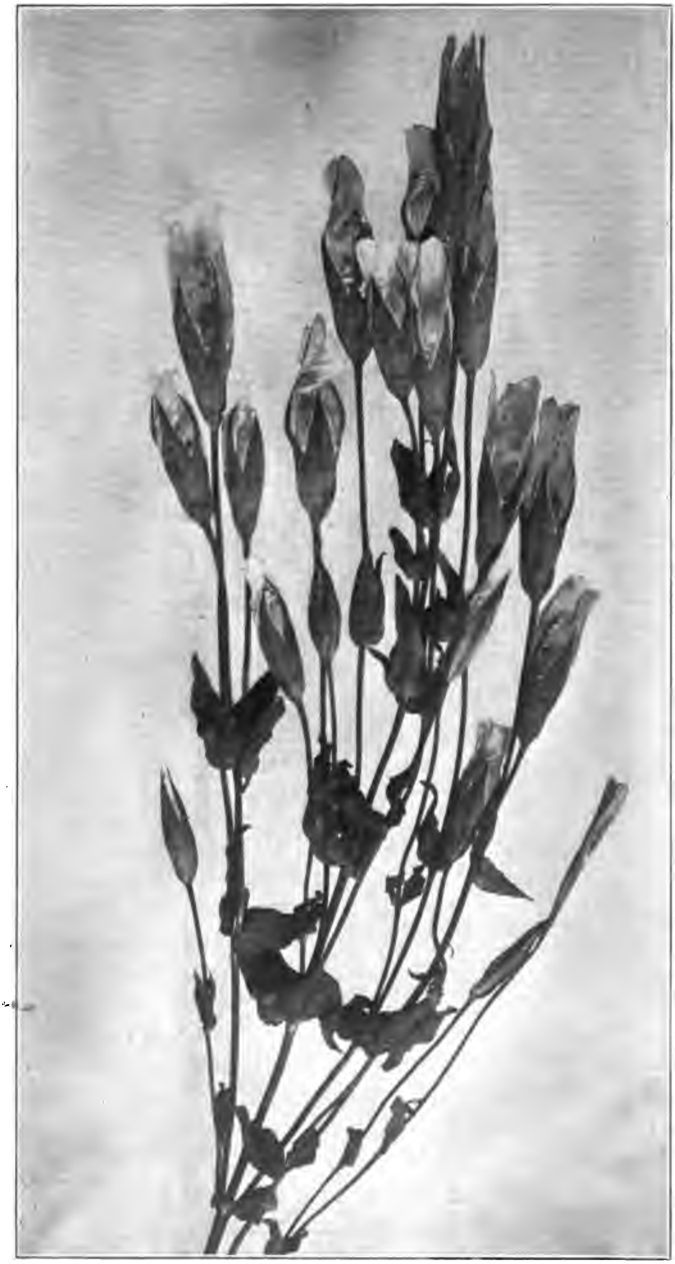

FIG. 26. *Gentiana crinita* in marshes and bogs of the Wisconsin drift. Photo. C. M. King

different than in northern Michigan, Wisconsin or Minnesota. The reason for this is no doubt the lack of forest-forming species in the immediate vicinity, the tamarack and spruce both being absent and no seed any where in the vicinity.

Steamboat Rock.

The Flora of the Flood Plains of the Iowa River.—This formation has in a large part lost its original aspect. The more important trees found here consist of the Soft Maple (*Acer saccharinum*), the Box Elder (*Negundo aceroides*), the Corky Bark Elm (*Ulmus racemosa*), *U. americana*, *Fraxinus viridis* and *Populus monilifera*. The shore line of the stream has an abundance of *Eragrostis reptans*, *Cyperus erythrorhizos*, *C. diandrus*, *Hemicarpha subsquarrosa*, *Lobelia cardinalis*, *L. syphilitica*, *Leersia virginica*, and *L. oryzoides*.

The second shore line consists of a black sandy humus. But a small proportion of the original forest remains The chief type of trees found here consists of the Hard Maple (*Acer nigrum*), *Juglans nigra*, *J. cinerea*, *Ulmus fulva*, some *U. americana*, and *U. racemosa*, *Carya amara*, *Quercus macrocarpa*, and *Q. rubra*, *Cratægus mollis* and *C. punctata*, *Pyrus iowensis*, *Prunus amer.*

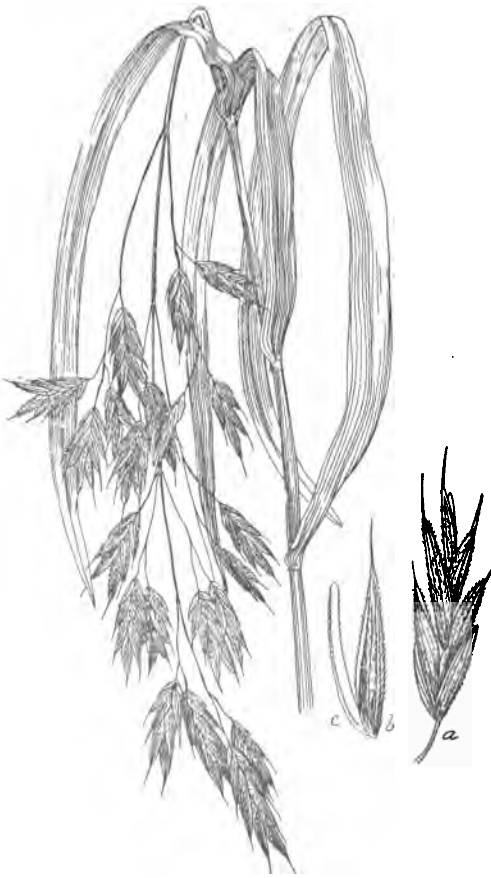

Fig. 27. *Bromus ciliatus* var. *latiglumis*. Common in marshes. Photograph by Charlotte M. King.

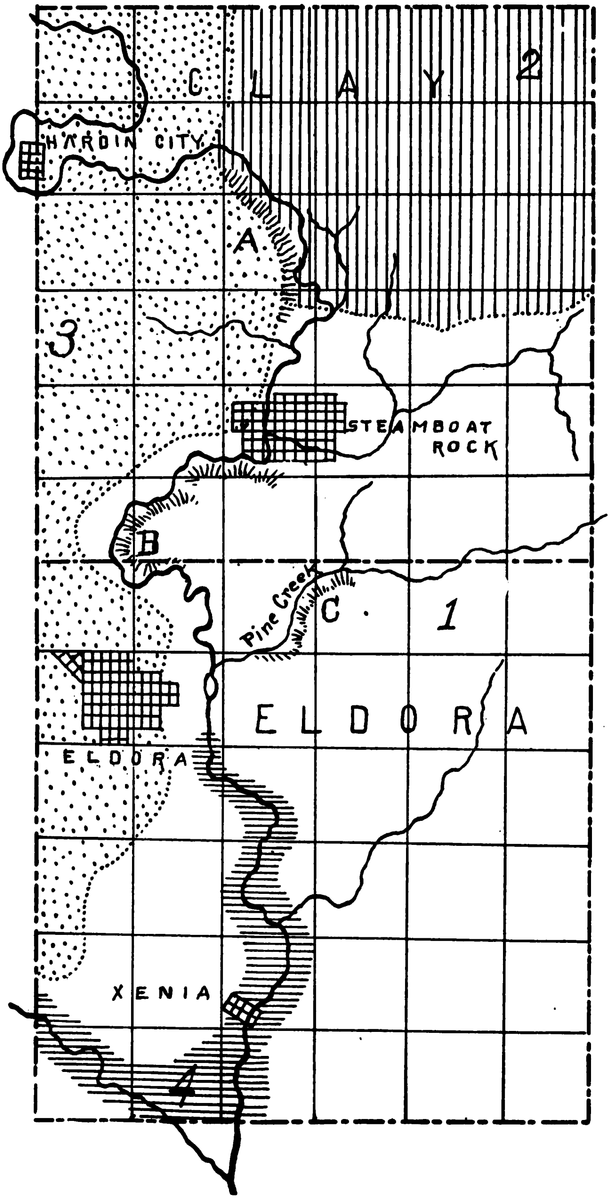

FIG. 28. Map of the Steamboat Rock region. The White Pine along Pine Creek and the Sandy Ledges between Pine Creek and Steamboat Rock. The Cherry Birch at B. 1=Kansan Drift. 2=Iowan Drift. 3=Wisconsin Drift. After S. W. Beyer.

Rocky Talus and Sandstone Ledges.—The rocky talus and sandstone ledges contain an interesting assemblage of boreal plants. The soil is black sandy loam with a rich humus. The narrow strip between the river and the vertical cliffs is shaded and contains a dense mass of plants consisting of several species that are quite rare in the state of Iowa.

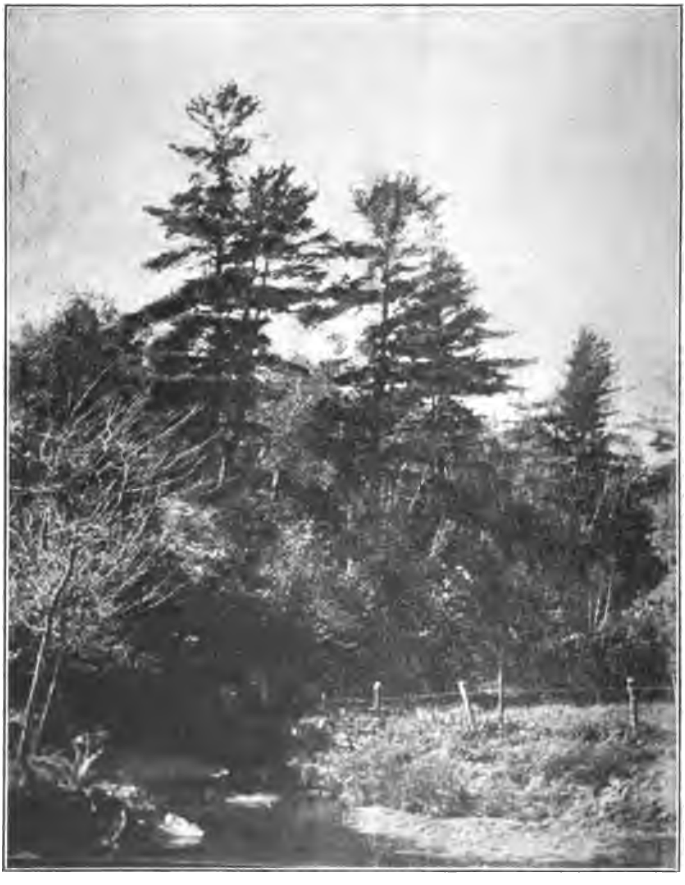

FIG. 29. *Pinus strobus*, *Betula papyrifera*, *Cornus circinata*, *Osmunda claytoniana*, *Smilacina trifolia* on Pine Creek, Hardin county. Photograph by Charlotte M. King.

Of the trees, the following are the more important: *Pinus strobus*, *Betula papyrifera*, *B. lenta*, and associated with these trees are the following shrubs: *Cornus circinata*, *Dierville trifida*, and

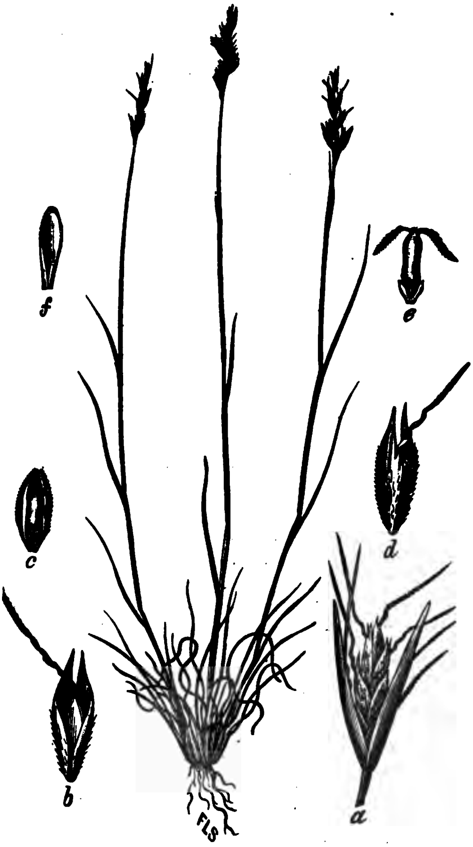

FIG. 30. *Danthonia spicata*, on the dry sandstone rocks. (U. S. Dept. Agrl.)

Lonicera sullivantii. Of the more common Iowa trees we may mention *Juglans cinerea*, *Quercus rubra*, occasional; *Acer nigrum*, *Juniperus virginiana*, *Cratægus margaretha* and *Amelanchier canadensis*. Of the herbaceous plants the *Aspidium marginale* is abundant for some distance underneath the shaded woods, along with it also the *Aspidium spinulosum* var. *intermedium*, *Polypodium vulgare* and *Phegopteris dryopteris*. The *Lycopodium lucidulum* is rare.

Along Pine Creek, where similar outcrops of sandstone occur but of less height, the White Pine is more abundant, there being trees here that are two to three feet in diameter and 70 or 80 feet high. Along the shaded places the *Osmunda claytoniana*, *Cornus circinata*, *Diervilla trifida*, and *Cypripedium spectabile* are abundant. Further up the Iowa river along the shaded bluffs where the Iowan drift occurs on steep banks the *Juniperus communis* is abundant. During the spring these banks are very moist. The *Cypripedium spectabile* is not infrequent, and *Salix discolor* and *Dirca palustris* are abundant. This region is always moist. The soil is a deep yellow loam overlaid by a black humus.

Of the many plants occurring upon the dry ledges, attention may be called to *Campanula rotundifolia*, *Danthonia spicata*, *Eragrostis capillaris*, *Lechea major*, *Heliathemum canadense*, *Erig-*

eron divaricatus and *Draba caroliniana*. In the shaded woods, during the early spring, under the sandstone ledges and elsewhere in the region, the *Trillium nivale*, *Viola pubescens*, *Isopyrum biternatum*, *Dicentra cucullaria* and *Anemone nemorosa* are abundant.

Percentage of Trees.

The percentage of trees found on different formations near Steamboat Rock is here given. The forests of Hardin and Marshall counties during the early days were important in the building of railroads as well as for fuel. It may be of interest, therefore, to give a table showing the percentage of trees on the different formations found in the vicinity of Steamboat Rock.

FORMATION.	SPECIES.	PERCENTAGE.
Sunny, sandy slope	*Quercus alba*	3.3
“ “ “	“ *rubra*	3.6
“ “ “	“ *tinctoria*	12.1
“ “ “	“ *macrocarpa*	12.1
“ “ “	*Ostrya virginica*	27.3
“ “ “	*Carya alba*	12.1
“ “ “	*Juglans cinerea*	9.9
“ “ “	*Tilia americana*	9.9
“ “ “	*Prunus serotina*	9 6
Rocky, sandv talus	*Quercus alba*	3.8
“ “ “	“ *macrocarpa*	19.6
“ “ “	“ *tinctoria*	26.2
“ “ “	*Prunus americana*	6.0
“ “ “	“ *serotina*	4.6
“ “ “	*Pruuus virginiana*	26.1
“ “ “	*Populus tremuloides*	7.9
“ “ “	*Cratægus mollis*	4.6
“ “ “	*Pyrus coronaria*	1.2
Sandy loam, north slope	*Prunus serotina*	12.1
“ “ “ “	*Juglans cinerea*	6.2
“ “ “ “	*Ostrya virginica*	20.0
“ “ “ “	*Acer nigrum*	12.0
“ “ “ “	*Carya alba*	20.0
“ “ “ “	*Betula alba*	1.9
“ “ “ “	*Cratægus margaretha*	5.5
“ “ “ “	“ *punctata*	2.2
“ “ “ “	*Quercus alba*	8.1
“ “ “ “	“ *rubra*	10.0
“ “ “ “	“ *tinctoria*	2.0
Black loam, top of hills	*Carya alba*	12.1
“ “ “ “ “	“ *porcina*	3.0
“ “ “ “ “	*Quercus tinctoria*	20.1
“ “ “ “ “	*Fraxinus americana*	2.5

Black loam, top of hills	*Fraxinus viridis*	1.5
“ “ “ “ “	*Tilia americana*	18.1
“ “ “ “ “	*Quercus rubra*	10.1
“ “ “ “ “	“ *alba*	10.0
“ “ “ “ “	*Ulmus fulva*	20.1
“ “ “ “ “	*Cratægus mollis*	2.5

The undergrowth in this forest consisted of *Rubus strigosus*, *Solidago ulmifolia*, *Silphium perfoliatum*, *Aster sagittifolius*, *Celastrus scandens*, *Helianthus strumosus*, *Ribes gracile*, *Cornus sericea*, *Corylus americana*, *Agrimonia eupatoria*, *Solidago canadensis*, *Prunus pennsylvanica*.

FORMATION.	SPECIES.	PERCENTAGE.
Carboniferous Sandstone, shady west slope, from rocky ledge to river	*Acer nigrum*	8.2
“	*Acer saccharinum*	3.0
“	*Fraxinus viridis*	4.5
“	“ *sambucifolia*	2.0
“	“ *americana*	2.0
“	*Betula papyrifera*	4.2
“	“ *lenta*	24.1
“	*Amelanchier canadensis*	10.4
“	*Juniperus virginiana*	1.0
“	*Ulmus fulva*	3.0
“	“ *americana*	3.0
“	*Pinus strobus*	2.17
“	*Quercus alba*	6.5
“	“ *tinctoria*	4.8
“	“ *rubra*	6.4
“	*Carpinus caroliniana*	4.4
“	*Ostrya virginica*	10.4

The undergrowth consisted largely of *Corylus americana*, *Diervilla trifida*, *Aspidium marginale*, *Phegopteris dryopteris*, *Cornus alternifolia* and *C. circinata*.

FORMATION.	SPECIES.	PERCENTAGE.
Sandy alluvial flood plains	*Populus monilifera*	3.1
“ “ “ “	*Quercus macrocarpa*	5.2
“ “ “ “	*Prunus serotina*	2.9
“ “ “ “	*Quercus rubra*	2.9
“ “ “ “	*Juglans cinerea*	17.4
“ “ “ “	“ *nigra*	15.3
“ “ “ “	*Negundo aceroides*	3.1
“ “ “ “	*Ulmus americana*	10.1
“ “ “ “	“ *fulva*	2.4
“ “ “ “	*Fraximus viridis*	8.1
“ “ “ “	*Acer saccharinum*	6.1
“ “ “ “	“ *nigrum*	15.6
“ “ “ “	*Pyrus iowensis*	2.9
“ “ “ “	*Prunus americana*	3.1
“ “ “ “	*Cratægus mollis*	2.5
“ “ “ “	“ *punctata*	2.0

These figures indicate that this sandy alluvial bottom contains species of plants that are common to other places in the region. This is no doubt due, in part, to the fact that the water does not long stand on the soil; then, too, the alluvial soil has a considerable mixture of sandy material, the soil being well drained.

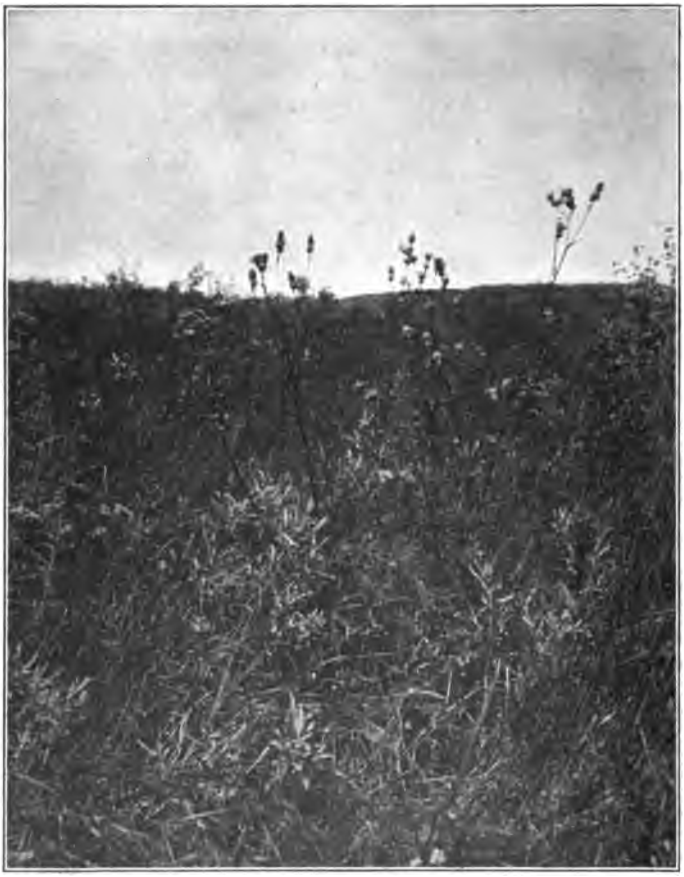

FIG. 31. Part of a Bog in Worth and Cerro Gordo Counties. *Cnicus mutians*, *Salix Candida*, *Lobelia kalmii*, *Bromus kalmii* and *Populus tremuloides* to the right. Photograph by L. H. Pammel.

The bogs of Cerro Gordo and Worth counties may be compared with some very typical swamps in Wright and Hamilton counties. Both of these counties are in the Wisconsin drift area, and the swamps are in a more advanced stage than in the north and east. These swamps have materially changed since the surrounding country has been brought into cultivation. That these swamps were once lakes, receiving the water from the surrounding country, admits of no doubt. The old beach line is plainly evident. In the larger of these lakes the outer beach was covered with trees and shrubs. Of this arboreal vegetation we may mention *Quercus macrocarpa*, *Ulmus fulva*, *U. americana*, *Fraxinus viridis* and *Tilia americana*.[1] There are few shrubs,—*Corylus americana*, *Rhus glabra*, *R. toxicodendron* and *Symphoricarpos occidentalis*. The smaller lakes are not surrounded by timber or shrubs. The outer beach line, which consists of a sandy gravel and humus, contains *Œnothera serrulata*, *Ceanothus americanus*, *Onosmodium carolinianum*, *Verbena stricta*, *V. bracteosa*, *Lithospermum canescens*, *L. angustifolium*, *Castilleia sessiliflora*, *Solidago rigida*, *S. nemoralis*. *Poa pratensis* is abundantly naturalized. The second beach is thickly covered with *Scirpus atrovirens*, *Glyceria nervata*, *Thalictrum purpurascens*, *Juncus tenuis*, *Verbena hastata*, and *Hordeum jubatum*. Formerly *Cypripedium candidum* was common. The third beach is thickly covered with *Carex*, *Iris versicolor*, *Lathyrus palustris*, *Eleocharis palustris*, *Eupatorium perfoliatum*, *E. purpureum*, and *Asclepias incarnata*. The third beach is mostly made up of *Calamagrostis canadensis*, *Glyceria*

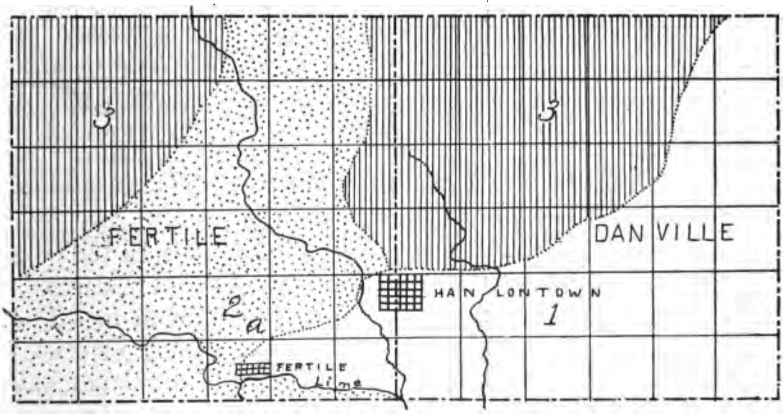

FIG. 32. Drift Sheets in Worth County. 1=Iowan, 2=Wisconsin, 3=Altamont Moraine.

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[1] See L. H. Pammel, "Old Lake Vegetation of Hamilton County, Iowa." Plant World, 2: 43.

arundinacea, *Carex*, *Hypericum* and *Scutellaria galericulata*. This beach is followed by an abundant growth of *Phragmites communis*, *Scirpus lacustris*, *Typha latifolia*, *Menythayhes trifoliata* and *Zizania aquatica*. Formerly the center of the swamp was a lake in which *Nuphar advena* and *Nymphœa tuberosa* abounded, but owing to drying of the lakes these have in most instances disappeared. During the spring and early summer months there is an abundance of water in the small depressions containing diatoms, desmids and other fresh water algæ. This water is fairly rich in bacteria. Of the several plates poured, we found the following number of bacteria per cubic centimeter:

Bacteriological Analyses of Water.

Story County. Pond.............	Agar.	Gelatin.	Colon Bacillus.
	2000	2800	Present
	2400		
	2800		

Pond near Eagle Grove Iowa......	Agar.	Gelatin.	Litmus Lactose Agar.
	3640	60	2400
	3500		3000

Other ponds, rivers and spring waters in the state contained bacteria per c. c. as follows:

Spring Water.—The number of bacterial organisms found in spring water differs greatly. Mr. Buchanan has called attention to Spirogyra Cladophora and various diatoms found in spring water. It may be of interest here to add the number of organisms found in spring water from different parts of the state under different conditions. Open springs running through low marshes contain more bacterial organisms than the protected springs, or those that are cased in.

Algæ were relatively few in number in the limestone region of Allamakee county. Some of these springs contained large volumes of water,—sufficient to make a good-sized stream.

	Media.	Agar.	Gelatin.	Lit. Lac. Agar
Living Goose Spring, Allamakee County.		2400	1000	3700
		4800		
Smith Spring, Allamakee County.		2800		1800
				350

River Water Supplies.

The number of organisms found in river water supplies varies greatly with the season. The following data may be of interest:

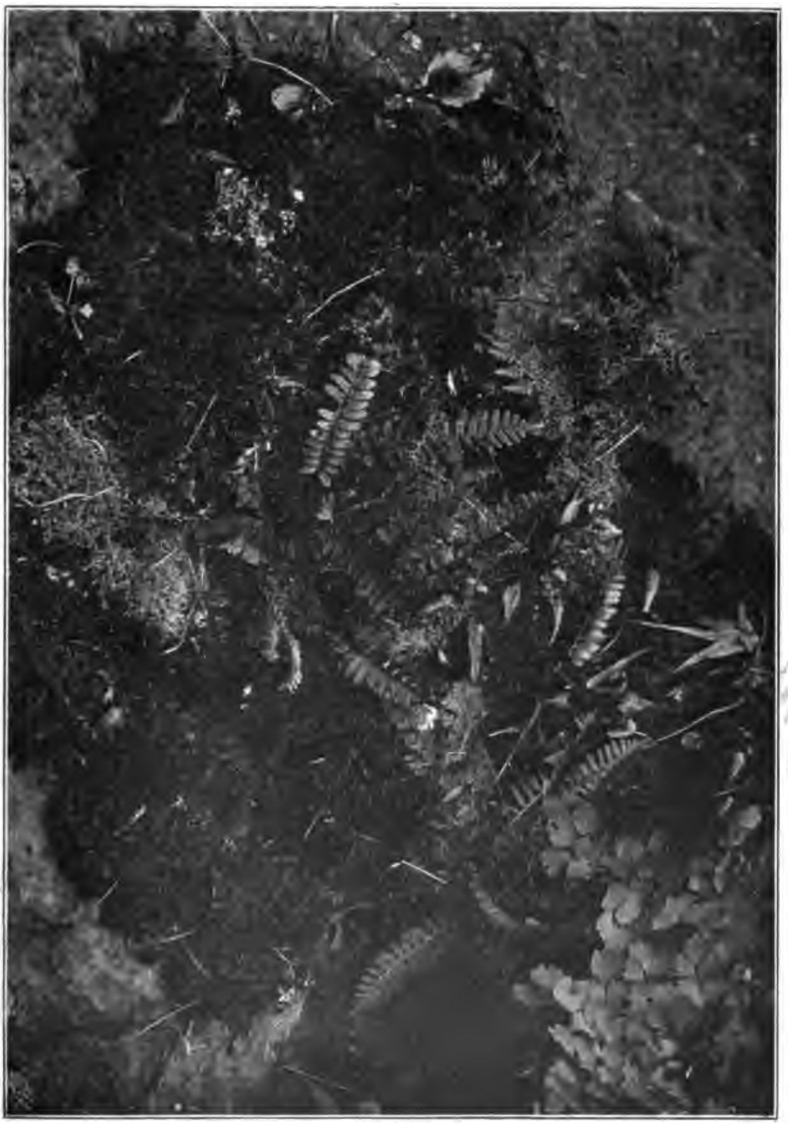

Fig. 33. Sandstone Region in Boone County, commonly called "The Ledges." Plants arranged. The *Cladonia* in dry open places. *Woodsia obtusa, Polypodium vulgare, Camptosorus rheizophyllus.* Moist sandy rocks. The *Adiantum pedatum* in moist woods, with *Cornus circinata* and *Viburnum pubescens.*

Skunk River.	Number Bacteria per c. c. on Agar.					
	3200	5000	10320	3080	10030	19200
	3240	2040	6200	1560		9080
	11410	16590	12040			
	10220		6650			

Iowa River.	Agar.	Lit. Lac. Agar
	3500	300

Mississippi River.	Agar.	Lit. Lac. Agar.	Gelatin.
	18906	5600	
	8400		
	8900		
	18000	5600	709

Des Moines River.	Hour.	Temp.	Bacteria per c. c., No. 1.	Same, No. 2
	10 a.m.	0°C.	40	
	11 a.m.	0°C.	1000	2750
	12 m.	0°C.	500	1800
	1 p.m.	1°C.	250	1000
	2 p.m.	1°C.	600	....
	3 p.m.	1°C.	250	500

The Carboniferous Sandstone in Boone County.

The Ledges.

These rocks have been formed under conditions similar to those of Hardin county. The flora is similar in some respects, but several important species have dropped out. There are no springs at present anywhere along Pease Creek, except in the prairie, though at the base of the rocks at Katina Falls a few small springs of good water occur. Pease Creek carries water during the entire year. This water comes largely from the meadows above the timber belt. The following plant formations occur in this region:

1. Sandstone formation, consisting of the
   a. Exposed dry rock.
   b. Moist talus and ledges.
2. The sandy, loamy, treeless slope. This again may be (a) dry or (b) moist.
3. The tree-covered slopes divided again into (a) moist exposures and (b) dry exposures.
4. Sandy bottoms along Pease Creek, (a) Mesophytic; (b) Hydrophytic.
5. Des Moines alluvium, (a) Forest, (b) Swamps.
6. Marshes above the coal measure shales.

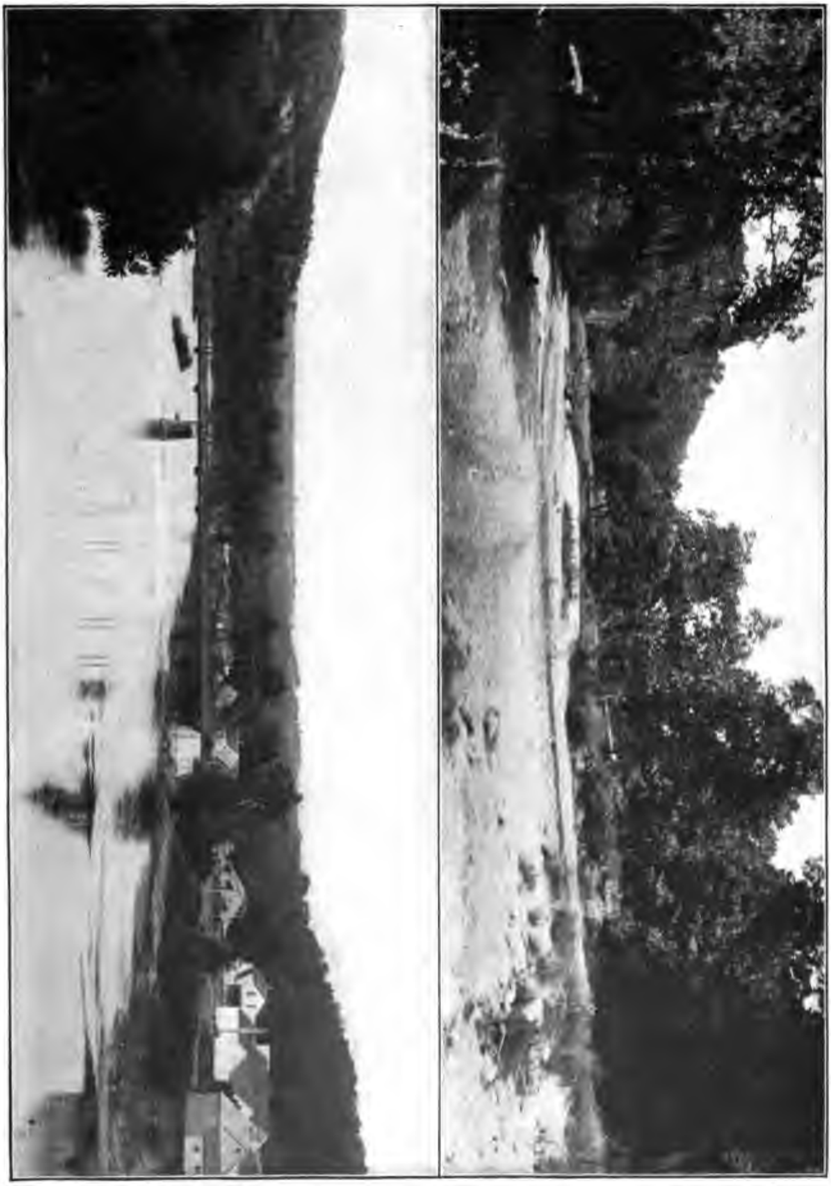

FIG. 34. The topography of the region about the ledges, Boone county, Iowa. Lower picture shows Moingona Bridge (Kate Shelley Bridge); the upper, alluvial region of the Des Moines near the ledges. *Acer saccharinum, Ulmus americana, Leersia virginica.*

1. *Sandstone Ledges.*—The Sandstone exposed dry rock contains some lichens, *Eatonia obtusata*, *Capsella bursa-pastoris*; *Taraxacum officinale*, *Erigeron canadensis*, *Chenopodium hybridum* and *Pilea pumila*. Many of the plants occurring here are annuals and make their growth in the spring. The moist rocks and talus contain *Aralia racemosa*, *Aralia nudicaulis*, *Camptosorus rhizophyllus*, *Cornus circinata*, *C. alternifolia*, *Galium aparine*, *G. boreale*, *Phryma leptostachya*, *Rudbeckia hirta*, *Woodsia obtusa*, *Cystopteris fragilis*, *Conocephalus*, sp., *Fragaria vesca*, *Polypodium vulgare*, *Mitella diphylla*, *Actaea spicata* var. *rubra*, *Prenanthes alba*, *Amphicarpæa monoica*, *Thalictrum dioicum* and *Teucrium canadense*.

Where sufficient age has been attained the rocks are covered with a mantle of clay and humus now overgrown with a good growth of young oak, (*Quercus rubra*), *Cornus circinata*, *Cornus alternifolia*, *Viburnum pubescens*, *Populus grandidentata*, *Acer nigrum*, *Juniperus virginiana*, *Rhamnus lanceolata*, *Quercus alba*, *Q. muhlenbergii* and *Amelanchier canadensis*. Of the herbaceous plants, *Thalictrum dioicum*, *Lathyrus venosus*, *L. ochroleucus*, *Cypripedium pubescens*, *Asarum canadense*, *Trillium nivale*, *Aralia nudicaulis*, *A. racemosa*, *Monarda fistulosa*, *Agrimonia eupatoria*, *Eupatorium ageratoides*.

The open spaces are covered with *Cladonia sylvatica*, *Polytrichum iuniperium*, *Helianthemum canadense*, *Lechea major*, *Danthonia spicata*, *Eatonia obtusata*, *Koeleria cristata*, *Euphorbia corollata*, *Petalostemon candidus* and *P. violaceus*.

The ferns are particularly noteworthy here. The walking leaf fern is found only in a few scattered places either upon the talus or upon the damp vertical cliffs. It is associated particularly with *Polypodium vulgare*, *Woodsia obtusata*, several species of moss, occasionally with *Mitella diphylla*, *Thalictrum dioicum* and lichens.

2. The sandy, loamy, treeless area occupies but limited portions of the region. In the more dry and exposed places the reindeer lichens, *Cladonia sylvatica*, and a variety occur, as well as *Agrostis scabra*, *Danthonia spicata*, *Polygala senega*, *Comandra umbellata*, *Polygala verticillata* and *P. sanguinea*, with a few Leguminosæ like *Amorpha canescens*, *Petalostemon violaceus*, *P. candidus*, and the Evening Primrose (*Œnothera biennis*), which is

more or less weedy, and such composites as *Taraxacum officinale*, *Aster multiflorus*, *Solidago rigida* and *S. nemoralis*, also *Lechea major* and *Helianthemum canadense* are the more important plants of the drier situations. In the more moist situations *Cladonia sylvatica* grows to greater perfection, frequently surrounded with an abundant growth of *Polytrichum commune* and another moss, *Funaria flavicans*. Among the earlier spring flowering plants we note the *Anemone nemorosa*, *Polygala senega*, *Aralia nudicaulis* and *Antennaria plantaginifolia*, forming large masses. Among the later plants *Hieracium canadense*, *Aster lævis* and *A. azureus* are found.

3. *Tree-covered Slope.*—The greater part of the tree-covered slope consists of trees common in central Iowa. At one time it was thickly covered with timber. However, the beginning of a young forest has speedlly taken the place of the old.

(a). Some of the plants found here are *Arabis lævigata*, *Aralia racemosa*, *Botrychium virginianum*, *Cornus alternifolia*, *Cornus circinata*, *Cystopteris fragilis*, *Desmodium nudiflorum*, *Galium aparine*, *G. boreale*, *Heliopsis scabra*, *Phryma leptostachya*, *Silene stellata*, *S. nivea*, *Viola palmata*, *V. cucullata*, *V. pubescens*, *Adiantum pedatum*, *Carpinus caroliniana*, *Ostrya virginica*, *Monarda fistulosa*, *Populus grandidentata*, *Lathyrus ochroleucus*, a very rare plant in central Iowa, *Quercus alba*, *Q. rubra*, *Carya amara*, *C. alba*, *Juniperus virginiana*, which more properly belongs to the dry talus, but there are scattered trees and shrubs throughout the woods, like *Rhamnus cathartica*, *Viburnum pubescens*, *Corylus americana*, and *Prunus pennsylvanica*.

(b). *Quercus muhlenbergii*, *Rhus glabra*, *Cornus candidissima*, *Bromus purgans*, *Arabis lævigata*, and a host of plants that are common to both regions, as the following: *Amelanchier canadensis*, *Cornus paniculata*, *Desmodium nudiflorium*, *Hydrophyllum appendiculatum*, *Populus grandidentata*, *Acer nigrum*, *Solidago ulmifolia* and *Asprella hystrix*.

4. *Sandy Bottoms.*—The fourth division contains many plants common to the upland, such as *Impatiens pallida*, *Astragalus canadensis*, *Œnothera biennis*, *Fraxinus pubescens*, *Agrostis perennans*, *A. alba*, *Poa pratensis*, *Laportea canadensis*, *Carex straminea*, *C. pennsylvanica*, *Panicum lanuginosum*, *Melilotus alba*, *Lithospermum latifolium*, *Cicuta maculata*, *Ulmus racemosa*, *Acer nigrum*, *Strophostyles angulosa* and *Lippia lanceolata*.

Of the hydrophytic plants few remain. *Spirogyra*, *Zygnema*, *Cardamine rhomboidea*, *C. hirsuta* and *Caltha palustris* are the more important plants occurring in the brook. The water in Pease Creek flows rather rapidly, so that few plants of this type obtain a foothold. They are, however, found attached to sticks or occur on the shores.

5. *Des Moines Alluvium.*—The character of the vegetation of the alluvial bottom of the Des Moines River is not essentially different from that in other sections in central Iowa. We have the soft maple (*Acer saccharinum*), *Negundo aceroides*, *Ulmus americana*, *Fraxinus viridis*, *Populus monolifera*, *Salix amygdaloides*, *S. longifolia* and *S. nigra* as the most important of the trees and shrubs. Under the shade of these trees or on the margin of the woods we find the following herbaceous plants: *Leersia virginica*, *Elymus virginicus*, *Panicum crus-galli*, *Pilea pumila*, *Bidens frondosa*, *Vernonia fasciculata*, *Aster tradescanti*, *Nasturtium palustre*, *Cinna arundinacea*, and *Spartina cynosuroides*. It

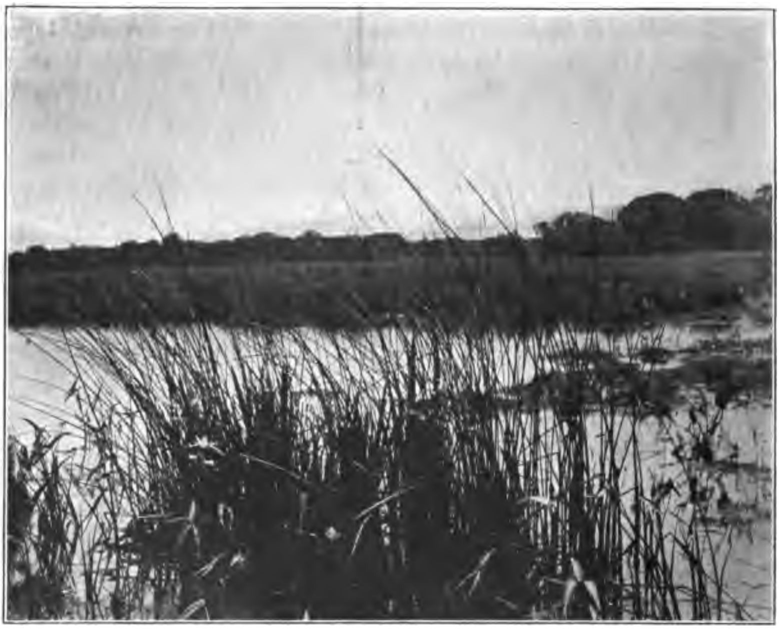

FIG. 35.—Marshes of the prairie region of central Iowa. *Scripus lacustris*, *Sagittaria*, *Ranunculus multifidus* and *Iris versicolor*. Story county, Iowa. Photo. by C. M. King.

is remarkable that the Sycamore, *Platanus occidentalis*, does not occur along the banks of the Des Moines in the vicinity of the Ledges (at least the writer has never seen it) while it is abundant at Ames, on the Skunk River, and Squaw Creek and also at Des Moines along the Des Moines and lower Coon. Dr. Beyer has shown that the Des Moines River during the post-glacial times had its course further eastward, flowing into what is now Skunk River just north of Ames. It is equally remarkable that the Buckeye, *Æsculus glabra*, does not occur on the Skunk River just north of Ames, nor for that matter in the country along the Skunk River, though common further southward. On the other hand *Æsculus glabra* is not infrequent along the Des Moines as far north as Frazer in Boone county. However, this species is found on the hills. What causes have operated to bring about this somewhat anomalous distribution can not be answered until a more extended investigation can be made of the causes that underlie the northward and southward extension of species.

(b) The swamps are adjacent to the Des Moines River. These swamps are not conspicuous in the vicinity of the Ledges as the banks rise rather abruptly. But where they are developed they appear at one time to have been bayous of the river. During times of high water they were filled and contained a large number of aquatic plants. These bayous have gradually been filled by the accumulation of sedimentary material so that near the mouth of small streams they have become flattened areas. During the spring of the year they are quite moist, since the drainage is not perfect. In the little depressions that are formed we find the more conspicuous plants to be *Iris versicolor*, *Typha latifolia*, *Lobelia syphilitica*, *Carex trichocarpa* var. *aristata*, and further on the drier uplands of the banks, *Carex stricta* and *Salix discolor*. Where drainage has been more perfect and the accumulation of a greater amount of sedimentary material has occurred, a high second bottom is frequently formed. These are not marshes in any sense of the word, but have been developed from the marshes just mentioned. In these alluvial upland bottoms the *Acer nigrum*, *Ulmus fulva*, *Celtis occidentalis*, with *Phlox divaricata* and *Asarum canadensis* form the more conspicuous plants.

6. The marshes above the coal measures, shales, carry moisture during the entire year. Here we find perennial springs.

Where there is much moisture they are treeless. A single typical area in the vicinity of High Bridge may be taken as a type. This area covers about two acres in extent and is typical of the numerous other small marshes found in the vicinity, and typical also for other marshes in central Iowa. The only shrubs occurring in the vicinity of the springs are the *Salix discolor* and *S. rostrata*. The banks surrounding the spring are covered with *Cardamine rhomboidea*, *Caltha palustris*, followed by *Cardamine hirsuta*, *Viola cucullata*, *Glyceria nervata*, *Lathyrus venosus*, *Thalictrum purpurascens*, *Calamagrostic canadensis*, *Eupatorium purpu-*

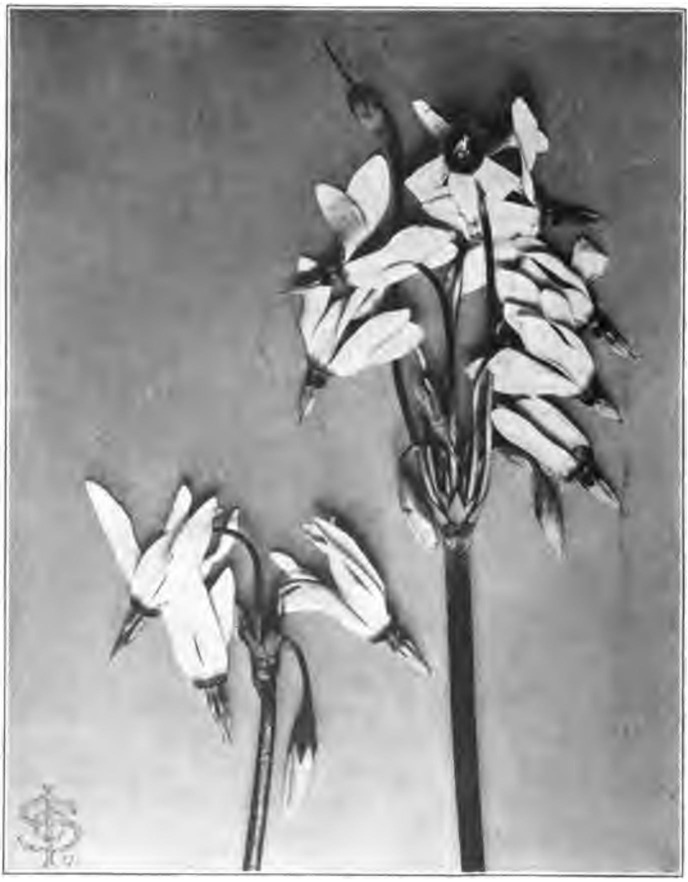

FIG. 36. Shooting Star (*Dodecatheon media*). On open prairie near Jewell Junction, Iowa.

reum, *E. perfoliatum*, *Chelone glabra*, *Aster umbellatus*, *Gentiana crinita*, *Cypripedium candidum*, *Aster salicifolius*, *Solidago serotina* and *S. ohioensis*.

7. *The Prairie Vegetation*.—The plants of this area are similar to the plants found in many other sections in central Iowa, especially that affected by the Wisconsin drift. The morainic flora consists of plants that are usually adapted to drier conditions. The *Anemone patens* var. *nuttalliana*, *A. caroliniana*, and *Draba caroliniana*, are rare plants. The more common plants of this drift material are *Viola pedata* and *V. pedatifida*, *Castilleia sessiliflora*, *Lithospermum angustifolium*, *L. canescens*, *Polytænia nuttallii*, *Ceanothus ovatus*, *Œnothera serrulata*, *Stipa spartea*, *Baptisia leucophæa* and *Rudbeckia hirta*.

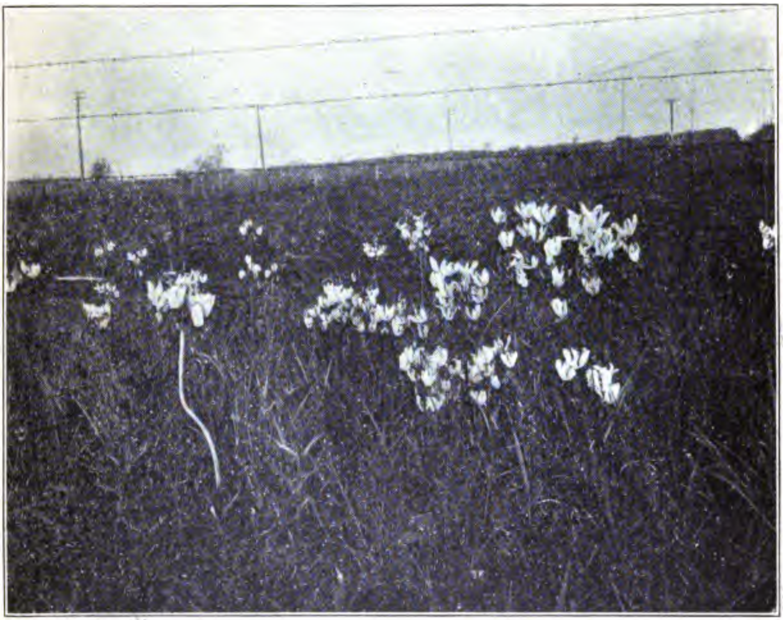

FIG. 37. A bit of prairie with *Dodecatheon media*, near Jewell Junction, Iowa.

The flora of the lower and flat areas consists of *Anemone pennsylvanica*, *Thalictrum purpurascens*, *Juncus tenuis*, *Panicum scribnerianum*, *P. virgatum*, *Liatris scariosa*, *L. pycnostachya*, *Vicia americana*, *Baptisia leucantha*, *Lilium philadelphicum*, *L. canadense*, *Spiranthes cernua*, *Lathyrus venosus* and *Cicuta maculata*.

In these ponds, which may become dry, the floating *Utricularia vulgaris* is common; *Carex trichocarpa* var. *aristata*, *C. crus-corvi*, *Scirpus atrovirens*, *Ranunculus multifidus*, *Iris versicolor* and *Phalaris arundinacea* occur; *Phragmites communis* and *Scirpus lacustris* are common.

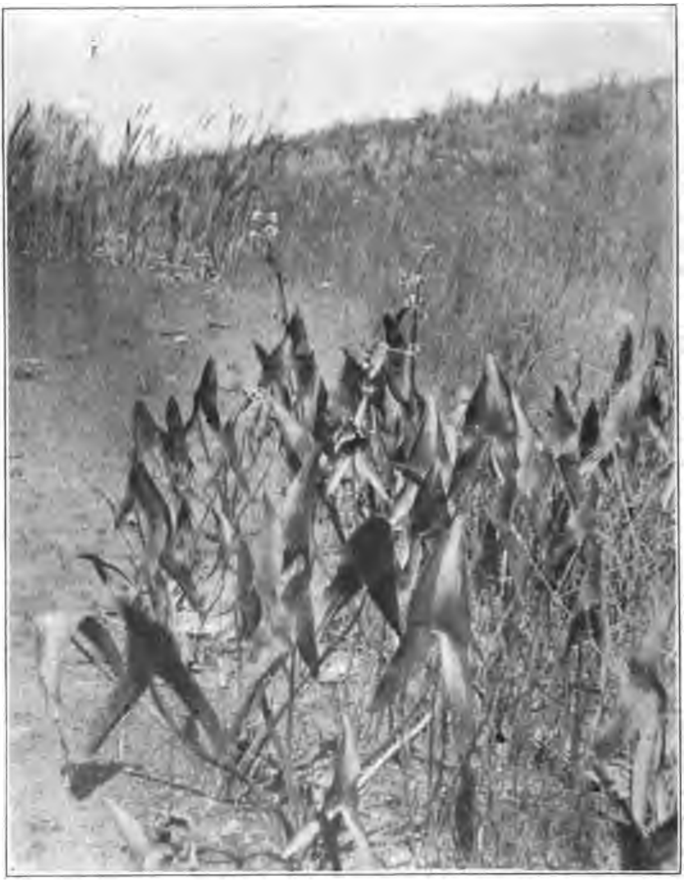

FIG. 38. *Sagittaria variabilis* and *Scirpus lacustris*. Many algæ are found in such ponds in the spring. These ponds may become partially dry towards the close of the season. Photograph by Charlotte M. King.

The Cordova Sandstone Ledges.—The Cordova sandstone ledges are somewhat similar to those of Boone and Hardin counties. They occur in Marion county, some distance southeast from Des Moines, along the Des Moines River. The boreal plant types have largely disappeared. The ferns consist chiefly of *Cystopteris fragilis* and *Adiantum pedatum.*

The trees found here are those common to central Iowa with the exception of the common occurrence of the Buckeye (*Æsculus glabra*) and *Cercis canadensis*, which occur at the base of the bluffs. The Redbud, while not present in the immediate vicinity of the ledges, does occur near Des Moines. The *Delphinium tricorne* grows in the rich soil at the base of the bluffs among the broken fragments of the sandstone rock. We note upon the tops of the bluffs two southern representatives, the *Poa trivialis* and *Myosotis verna*. *Cerastium nutans* and *Cynthia virginica* are also common, though absent in Hardin and Boone counties. The *Poa trivialis* is generally considered native of northern Europe but it is undoubtedly indigenous to this country. If we compare these regions with the Pine Creek region of Muscatine county, farther southeast on the Mississippi, we find the following very interesting facts.

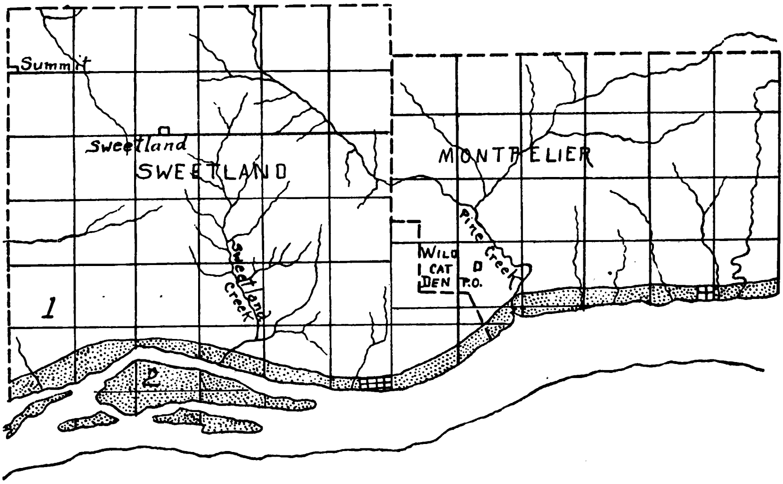

FIG. 39. Map of the Pine Creek region, Muscatine county, Iowa. 1=Iowan loess; 2=Alluvium. The White Pine, *Gaylussacia*, *Phegopteris hexagonoptera* and *Aspidium lonchitis*, found in the Pine Creek region. After Iowa Geological Survey.

Pine Creek Region of Muscatine County.—The Pine Creek region of Muscatine County contains among other plants the following: *Circæa alpina*, *Aspidium acrostichoides*, *Gaylussacia resinosa*, *Panicum glabrum*, *Aspidium cristatum*, *Camptosorus rhizophyllus*, *Asplenium thelypteroides*, *Adiantum pedatum*, *Pteris aquilina*, *Polypo-*

dium vulgare, *Lycopodium lucidulum*, *Osmunda claytoniana*, *O. cinnamomea* and *O. regalis*.

The White Pine in Muscatine county is the most southern extension of the species in the state of Iowa. On the slope of the hills other trees common to the state, like *Juglans cinerea*, *Quercus alba* and *Q. rubra*, occur.

Lespedeza violacea and *L. reticulata* occur in drier soil. *Cercis canadensis*, *Cerastium nutans*, *Arenaria latifolia*, *Goodyera pubescens*, *Fragaria vesca*, *Convolvulus spithamaeus*, *Agrimonia parviflora*, *Spirea aruncus*, *Rubus cuneifolius*, *Aster cordifolius*, *A. corymbosus*, *A. macrophyllus*, *Chelone glabra*, *Gerardia tenuifolia* var. *asperula*, *Maianthemum canadense*, *Camassia fraseri* are other species of the region.

Of the rarer plants occurring in this vicinity, but not on these sandstone bluffs, mention may be made of *Rhexia virginica*, *Phlox bifida* along the Cedar River; *Symplocarpus foetidus*, *Allium tricoccum*, *Calopogon pulchellus* in boggy places in the Cedar River region; *Dodecatheon meadia* is rather common on prairies; *Angelica atropurpurea* in low lands. *Cicuta bulbifera*, *Pentstemon grandiflorus*, *Breweria pickeringii*, *Cristatella jamesii*, *Helianthus petiolaris* and *Panicium autumnale* is more or less common on Muscatine Island.

Mr. R. E. Buchanan has contributed the following on the Algal Flora of the region. The algæ were listed by Dr. Bessey.[1]

NOTES ON THE ALGAL FLORA OF THE REGION.

BY R. E. BUCHANAN.

No collections were made of the algæ from southwestern Wisconsin, but the following method furnished us with the names of a few of the algæ that are abundant in that locality. Three types of the soil of that locality were placed in separate sterile jars and covered with water. Each of the jars soon developed an abundant growth of the algæ.

The peat soil naturally was by far the most productive of forms. The relative abundance of the organisms as they occur in the peat naturally and in the aquarium was certainly different,

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1. Bull. Ia. Agr. Coll., Bot. Dept., 1884: 139.

but all those that were found are fitted just as certainly for life in the peat bogs of that country. The list of forms is as follows:

Oscillaria tenuis.
Oscillaria natans.
Anabæna flos aquæ.
Scenedesmus dimorphus.
Scenedesmus obtusus.
Tetraspora lubrica.
Protococcus viridis.
Ulothrix zonata.
Chætophora elegans.
Gonium pectorale.
Gomphonema constrictum.
Cymbella cuspidata.
Synedra sp.

The other two soils examined in this manner were a yellow clay and a yellow loam. The same organisms developed in both of these jars. Neither of these soils was, of course, naturally under water. The algæ therefore are of a character to take advantage of any increase in moisture, to make a rapid growth, and to resist dessication. The list of organisms is as follows:

Oscillaria violacea.—Forms a dense mat over the surface of the clay. Bubbles form underneath and it is forced up until it floats.
Nostoc muscorum.
Oscillaria tenerrima.
Stauroneis sp. Very minute.

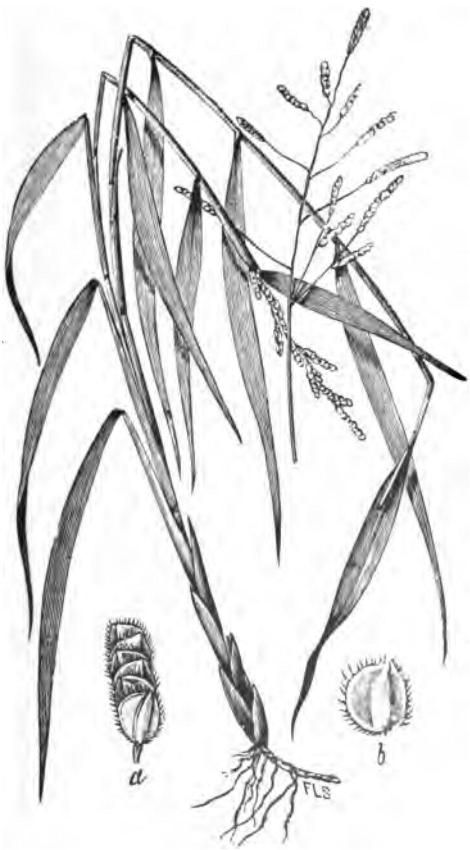

FIG. 40. *Leersia lenticularia* in low grounds along the Mississippi. (U. S. Dept. Agrl.)

The only collection of algæ from northeastern Iowa that was examined was one that came from the effluent of one of the large springs that issue from the limestone rocks of that region. It consisted of a dense mat of *Vaucheria sessilis* in fine fruit. The collections that have been made in the vicinity of the Ledges in central Iowa have been more numerous. Here are to be found a number of springs, ledges of limestone and sandstone rock, creeks and the Des Moines River. The algal flora is therefore very varied and mention can be made of a few only of the many forms.

The water that issues from the springs of this region supports a very characteristic flora. The shallow, cold, clear water seems to be a favorite locality for the *Vaucheria*. These are of the two species, the *V. sessilis* and the *V. geminata racemosa*. These mats, sometimes several feet in diameter and an inch thick, are the home of a large number of diatoms. Wherever the water trickles in fine streams along the surface of the rocks will be found the *Nostoc muscorum* and the *Scytonema*. These, with the *Pleurococcus*, form the gonidia of the hundred or more lichens that are to be found in this locality. In one little pool exposed to the full rays of the sun and quite warm, the *Rhaphidium polymorphum* was so abundant that the whole mass of the water was of a dark green.

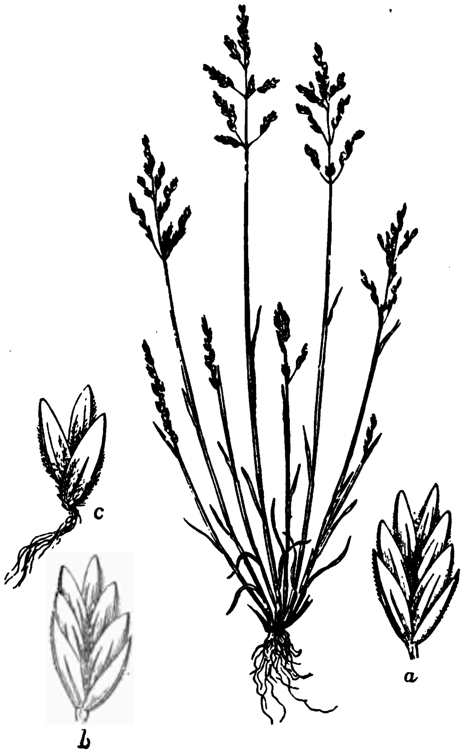

FIG. 41. *Poa chapmaniana* in fields and flood plains of southeastern Iowa. (U. S. Dept. Agrl.)

The rocky streams that cut through these ledges of rock, have as their most conspicuous alga the *Tetraspora cylindrica*. At times during the summer the stones in the bed are covered with long streamers of this alga. These sometimes reach to a length of several feet. Diatoms of many species are here to be found also. In the quiet pools may be found masses of the *Spirogyras*, such as *S. crassa* and *S. fluviatilis*, together with *Closteriumlanceolatum* and *Zygnema stellium*.

The Des Moines River at this point is deep and muddy, offering a very poor chance for any considerable growth of the algæ. In some of the quieter bayous and the shallows, however, a few forms may be found. Among these are the following:

Merismopedia glauca.
Nostoc commune.
Anabæna flos-aquæ.
Cylindrospermum macrospermum.
Oscillaria tenuis.
Oscillaria viridis.
Tetraspora lubrica.
Characium naegeli.
Tetrædon longispinum.
Closterium acerosum.
Zygnema stellium.

Spirogya deciminata.
" *maiuscula.*
" *varians.*
" *dubia.*
Vaucheria sessilis.
Microspora abbreviata.
Ulothrix subtilis.
Stigeoclinum tenua.
Cladophora fracta.
Euglena viridis.
Œdogonium capillare.

The above is not the result of any single collection, but of several collections at different times. Further collecting would probably considerably extend the list.

Some Local Problems in the Geographical Distribution of the Wisconsin and Iowa Flora.

Several interesting problems on the geographical distribution of plants in the areas under consideration may now be discussed. Mr. C. C. Adams has shown that southeastern United States is a center of the geographical distribution of a part of our flora.[1]

Dr. John W. Harshberger, in his recent phytographic sketch of eastern and southeastern Pennsylvania, states as follows: "With the retreat of the great ice-sheet, the region once covered by the ice was restocked by trees and herbs derived from three main sources of supply: (1) Scandinavia, (2) Hudsonian zone of the Glacial period, (3) Appalachian forests (north and south). The Scandinavian plants migrated eastward during the interglacial peroid and tenanted the moraines, nunataks and arctic strip of territory throughout the later glacial epoch. With the retreat of the glaciers, they migrated northward with the ice sheet, or they persisted on the tops of high mountains which existed as nunataks during the ice age, or they remained as boreal islands in sphagnum bogs, or in cold and shaded ravines. A northward migration of Hudsonian species and of Appalachian species in concentric waves also took place at the close of the Glacial period.[1]

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[1] Biological Bull., 3: 123.

The action of the several uplifts and depressions of the earth's surface described was most profound upon this forest, the history of which has been traced. With every submergence of the lower portions of the creeks of the region and of the Delaware river, the forest in the area of submergence was destroyed, or if existing on the higher grounds, was subjected to such extensive changes of level as to modify its character and the distribution of the component species. Many species were crowded together by the change of level and the wearing away of the strata to which they had become adapted, for "if we suppose the earlier Mesozoic uplands to be the seat of the existing dicotyledons, then by the lowering of the surface by gradual consumption of the interstream areas, these forms must have been brought into conflict with the flora of the lowlands and thereby forced into a contest for supremacy."[2]

Dr. Livingston, in a discussion of the forests of Roscommon and Crawford counties, says: "The hardwood forest reappears quite rapidly when cut. This is doubtless in part due to the fact that this material does not burn so readily nor so violently as do the pines. The scattered white pines which formerly characterized some of these forests in the eyes of the lumberman are not returning. They are perhaps only a relic of a past generation of forest. Hemlock is reproducing well and will return with the beech and maple if, through lack of humus, the soil does not become too dry for the seedlings. Its seedlings stand close together and do not seem to suffer from one another's shade."[3]

It seems to me that the floras found at several different points, of the region here considered, especially the coinfers, are relics of a flora once abundant in this region.

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[1] Cf. Adams, C. C. Post-Glacial Origin and Migration of the Life of the Northeastern United States. Jour. Geol., 1903: 303.

[2] Woodworth, J. B. The Relation Between Baseleveling and Organic Evolution. Am. Geol., 14: 231. 1894.

[3] Bot. Gazette, 39: 38.

A few of our bog plants, *Pyrus arbutifolia*, *Nemopanthes fascicularis*, and *Rhynchospora alba* are southern and have migrated northward from the southern Appalachians, as suggested at least for the *Pyrus* by Transeau. The *Vaccinium corymbosum*, *V. atrococcum*, *Rhodora canadensis* and *Viburnum cassinoides* have not extended to our region. The *Gaylussacia resinosa*, though occurring in swamps, is not found in any of the bogs that I have studied, in either Wisconsin or Iowa. It does, however, occur in rocky woodlands of Muscatine county. It must be added to the immigrants from the southeast. One of the most striking immigrants from the southeast is *Rhexia virginica*, which occurs in the sandy swamps of the Cedar River near Muscatine. Nowhere in the region do the southern forms reach an optimum of development; they are crowded out by other dominant types; the same is true of the boreal types found here. The *Linnæa borealis*, *Vaccinium macrocarpon*, *Calopogon pulchellus*, *Pogonia ophioglossoides*, *Sarracenia purpurea*, *Drosera rotundifolia*, *Gentiana crinita* and *Campanula aparinoides* are some of the more important immigrants from the north.

These plants are, however, very local. Of wider distribution in swamps, the *Cnicus muticus*, *Menyanthes trifoliata*, *Valeriana edulis*, *Saxifraga pennsylvanica*, *Lobelia kalmii*, *Viola blanda* and *V. lanceolata*, reach over into Iowa. *Ledum latifolium* does not occur in our region, but near Kilbourne City, on the sandy rocks of the Dalles of the Wisconsin, it is found with *Thuya occidentalis*, *Pyrus americana* and *Aspidium fragrans*. The *Betula pumila* is quite common in the swamps of western Wisconsin, especially tamarack, but it scarcely reaches into Iowa. The *Salix candida* is common in similar places, and reaches over into Worth, Cerro Gordo and Winnebago counties, and south to Johnson county. There are, however, few stations south of Cerro Gordo county. The *Salix lucida* is common in tamarack swamps and extends down to Buchanan county, Iowa, two localities being given by Ball in his paper on "The Genus Salix in Iowa." The *S. rostrata*, though a tree, is generally of small stature in western Wisconsin and southeastern Minnesota. It is commonly found where the Wisconsin drift occurs and southeast to Johnson county, according to Ball. The *S. discolor* and the boreal willow are much more common in the swamps of northern

Iowa which occur from Dickinson, Boone, Monroe and Henry counties in the southeastern part of the state.

The *Taxus canadensis* is common in Wisconsin and extends south into Iowa as far as Linn county. The White Pine is most interesting in its distribution. It occurs in isolated areas as far south as Montpelier township in Muscatine county, the most southern point in Iowa. The groves in northeastern Iowa are larger and more frequent. In Hardin county there is one small area isolated from the areas in eastern Iowa. It is, however, more than probable that the species once had a much wider distribution.

There are well-preserved conifers in drift material from various parts of Iowa. Through the kindness of Mr. Savage I have been permitted to examine some wood in a fairly good state of preservation found in the southwestern part of the state. The wood appeared to be Red Cedar and Hemlock (*Tsuga canadensis*). Well-preserved wood has also been found in wells at a depth of 60 feet in northeastern Iowa. One piece was 14 inches long. According to Mr. Orr, these were probably conifers. They occur between the Iowan and Kansan drift. It is more than probable that coniferous forests once covered the entire state. Indeed Dr. Bessey thinks that in recent geological times coniferous forests were common in Nebraska.[1] The *Abies balsamea* is also a boreal species and occurs in an isolated area. The only point at which it occurs is in northeastern Iowa. It does not occur in western Wisconsin nor southeastern Minnesota. The *Larix americana* is more abundant, but is an exclusive swamp species. Of the four common trees found in swamps, the Black Spruce, Arbor Vitæ, Balsam and Tamarack, the latter is not uncommon in western Wisconsin. The balsam is found in northeastern Iowa, while the others are wanting in the area under consideration. The genus *Betula* is interesting from the standpoint of distribution. The *Betula papyrifera*[2] is common in western Wisconsin and northeastern Iowa. It is rare south of Dubuque on the Mississippi. Hardin county is the western limit in Iowa. *Betula lenta* occurs in western Wisconsin on sandy rocks, and in southeastern

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[1] Annual Report, Neb. St. Bd. of Agr., 1888: 93.

[2] Betula alba.—Contr. Gray Herb., Harv. Uni., new ser., 23: 169. Amer. Jour. Sci., 14: 169: 1902.

Minnesota. It drops down into southeastern Minnesota, but is a rare tree. It is fairly common in one place in Hardin county, along the Iowa river at the base of sandstone ledges. The *Betula pumila* has been referred to as common in swamps in western Wisconsin.

It does not seem probable that the *B. lenta* was scattered by the northeast winds from northeastern Iowa, for at the time when the seeds are ripe the winds are usually west and southwest. The same may be said of the *Betula lenta*, which is not uncommon on the sandy rocks of the rivers of western Wisconsin in the latitude of La Crosse and in isolated places in western and southeastern Minnesota. The wind has played scarcely any part in its distribution in central Iowa. River Birch (*B. nigra*) no doubt owes its northern extension to its wind-dissemination. Its distribution may also have been aided somewhat by the water. Three conifers may briefly be mentioned as wind-disseminated. They are *Pinus strobus*, *P. resinosa* and *P. banksiana*.

P. banksiana is common only upon the pine barrens of the La Crosse River and northward and eastward. *P. resinosa* is found in a few outlying stations along the Black River, between Galesville and La Crosse, and is not uncommon on the east branch of the Kickapoo near Rockton. The White Pine and the *Larix americana*, as mentioned elsewhere, are more widely distributed.

The white pine in Hardin county was scarcely brought by the wind in recent times from northeastern Iowa. There are evidences of wind-dissemination of the larch and white pine for six or seven miles and the larch probably has been carried twelve miles. Generally speaking, the wind-disseminated plants are scarcely scattered as far and wide as those by birds.

Of the genus *Prunus*, the *P. pennsylvanica* is common in northeastern Iowa, Wisconsin and Minnesota. It is quite common in Hardin county, but rare in Story county, except in a few localities. In Boone county it is found on the sandstone ledges. The *P. serotina* is generally distributed in eastern Iowa, reaching out to central Iowa. The *Juglans nigra* is found everywhere on the larger streams like the Des Moines, Iowa, Cedar and Skunk rivers. The *Platanus occidentalis* is another southern species which has made its way northward along all the larger streams, nearly reaching the Minnesota line.

The *Carya sulcata*, so common southward, is found on Muscatine Island and in southeastern Iowa. The *C. tomentosa* is of somewhat wider distribution, but does not reach much further north than Muscatine. The Pecan is found as far north as Sabula.

The *Gymnocladus canadensis* reaches to the Minnesota valley. The *Morus rubra* is found in Houston county, Minnesota. In Iowa it is local but occurs in woods along the larger streams, at Des Moines, Boone, Ames and Missouri Valley. The water courses have been important factors in the distribution of our trees and shrubs. Of the trees disseminated by birds, the *Celtis occidentalis*, a species of *Cornus*, the *C. paniculata*, *C. candidissima*, *Vitis riparia*, *Rhus toxicodendron*, *R. glabra*, *Amelanchier canadensis* and *Rosa blanda* are of wide distribution. The *Symphoricarpos vulgaris* and *S. occidentalis*, *Cornus stolonifera*, *Vitis cincrea*, *Rhus venenata*, *Morus rubra*, *Vaccinium macrocarpon*, *V. pennsylvanicum*, *Gaultheria procumbens*, *Arctostaphylos uva-ursi* and *Viburnum opulus* are annual, of somewhat local distribution; very local indeed are the cranberry, blueberry, bearberry and poison oak (*Rhus toxicodendron*), *Vitis cinerea* and the two species of *Symphoricarpos*, one, the *S. vulgaris*, is southern, while the other is northern, quite as common in the Rockies as in Minnesota and Wisconsin. In Wisconsin and southeastern Minnesota it is found upon the bluffs. In Iowa it is abundant upon the loess soil upon the Missouri and the borders of the lakes in northern Iowa.

The seeds of this have no doubt been widely scattered by birds, but it was only when conditions were favorable that growth occurred. Now, if we take into account wind-disseminated shrubs and trees, the conditions for wide scattering are less favorable. Most of our streams in the area are considered to flow in a southeasterly direction. This is true at least of the larger streams. The Mississippi River, although somewhat tortuous, is, however, an important exception. Our winds are either from the north, south, east or west, and it is rather exceptional to have the winds blow any great length of time from the southeast or northwest, hence the chances for scattering of seeds for great distances along the streams are less favorable, except on the Mississippi. Of the wind-disseminated trees the more important are the willows, the *Salix cordata*, *S. amygdaloides* and the shrubby willows, which are generally common along the streams. The cottonwood, *Populus monilifera*, is found in all parts of the state, except the very small tributaries. By nature the tree prefers alluvial soil. However, since the settlement of the state, the species has become more or less widely scattered in railroad cuts, gravel beds and stone quarries.

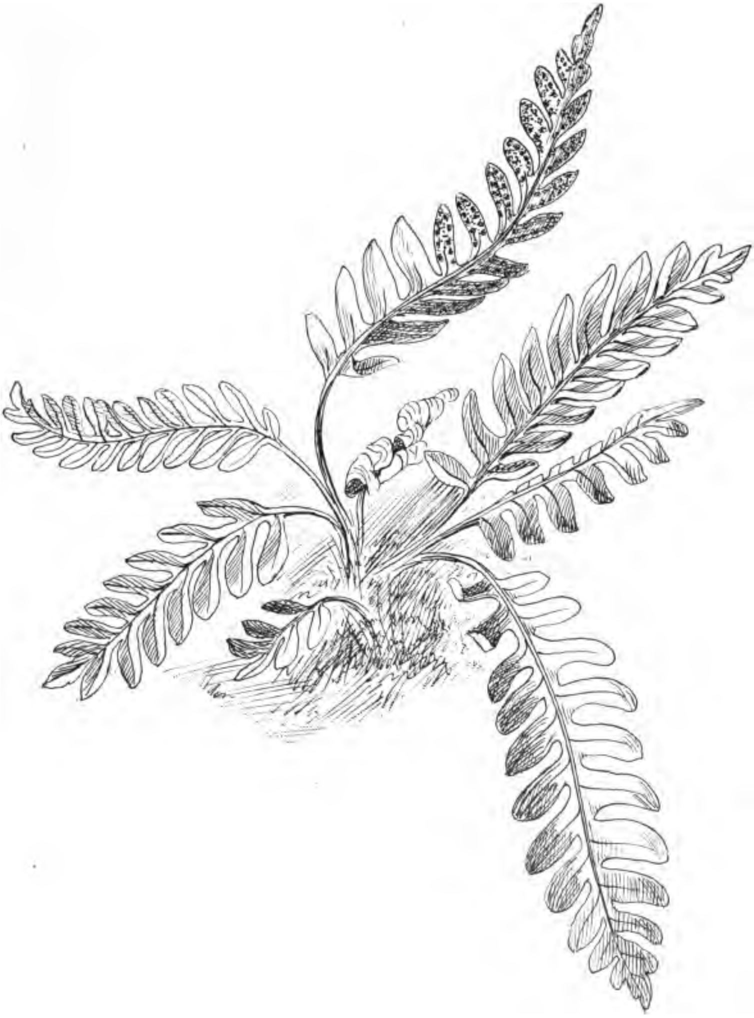

FIG. 42. Common Polypody (*Polypodium vulgare*). Sandy rocks and ledges of Boone county, Iowa. Photograph by Charlotte M. King.

Other animals have aided in the dissemination of some of our trees and shrubs. There can be no doubt that the genera *Quercus*, *Juglans* and *Carya* are largely disseminated by squirrels, and in former times larger animals no doubt also helped to disseminate *Rubus strigosus*, *Amelanchier canadensis*, *Arctostaphylos* and *Vaccinium*. These plants show the same northbound and southbound movements that the bird- and wind-disseminated plants do.

The other species of *Populus*, the seeds of which are scattered by the wind, may be mentioned, viz., the *Populus tremuloides* and *P. grandidentata*, the former more abundant in northeastern Iowa, Wisconsin and Minnesota than in central Iowa. It is the only species native around the swamps in Cerro Gordo and Worth counties. The *P. grandidentata* is abundant everywhere in Wisconsin, Minnesota and northeastern Iowa, and reaches over into Hardin and Boone counties, common only upon the carboniferous sandstone in central Iowa, while in Wisconsin and Minnesota it is common upon the St. Croix sandstone.

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